Heating · Piping and Air Conditioning
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Air Conditioning

fast becoming standard equipment for

Railway Passenger Cars

Union Pacific's New "Train of Tomorrow" Has Complete Air-Conditioning System

INCLUDING numerous features for safe, high-speed operation and for providing maximum comfort and convenience to passengers the Union Pacific's new stream-lined train was completed just last month at the plant of the Pullman Car & Manufacturing Corporation. The train is equipped with an air conditioning and heating system possessing several unusual features.

The U. P. calls it "tomorrow's train today," and it has already attracted nation-wide interest. Now touring the country, it is to be operated on special runs between larger cities on the Union Pacific System to demonstrate its practicability for regular main-line through passenger service, including transcontinental. While this first train does not have sleeping accommodations, the U. P. has ordered a second such train to consist of a power car with a 900-hp, 12-cylinder, V-type diesel engine, a mail-baggage car, three Pullman sleeping cars and a combined coach and observation buffet car.

Features of Construction

As will be seen in an accompanying drawing, the train consists of three cars; articulation between the body units permits its being carried on four trucks instead of six. The cross-section is tubular, the entire car body forming a beam, this design requiring a minimum of material for a given strength. The car bodies are formed of two structural elements—namely, extruded aluminum alloy shapes in combination with aluminum alloy plates forming the outer and inner sheathing.

In the 2-in. space between the sheathings is placed a mineral-fiber insulation, the fibers of which are interwoven to the required thickness and backed with asbestos cloth. Applied to the sides, floors, roofs and ends of the cars, this insulation is held in place by wires.

The single-pane windows, of shatter-proof glass, are flush with the outer sheathing to preserve the streamlining and are sealed shut in rubber. The insulation of the train, the sealed windows and the smaller cross-sectional area of the cars contributes to economy in air conditioning.

The appearance of the train is as unusual as its many mechanical and constructional features; the exterior is painted a golden brown and a canary yellow (for visibility), the colors being separated by a red stripe—all highly finished. The interior decoration is "modern," blue and aluminum being the motif.

The Power Plant

The main power plant of the train consists of a 12-cylinder, V-type distillate-burning, internal-combustion engine rated at 600 hp directly connected to a generator supplying current to two motors mounted on the forward truck of the first car. In addition, there is a 25-kw

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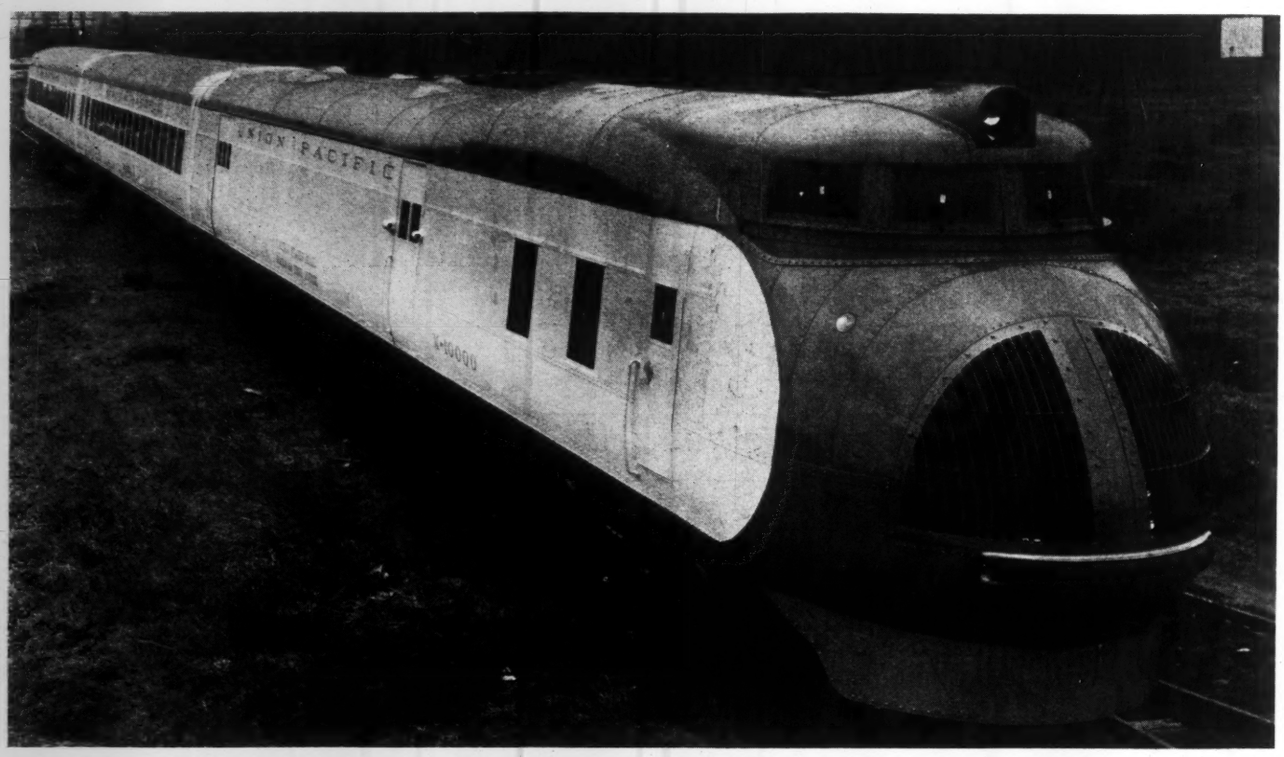
THAT AIR CONDITIONING is rapidly becoming standard equipment for railway passenger cars is evidenced by the present activity in installing air conditioning systems in cars. As compared with 1933, there will be several hundred additional air-conditioned railway cars in service this year. One of the most talked of railway air conditioning jobs right now is the new Union Pacific stream-lined three-car train. The features of its unusual air conditioning and heating system are described here, as are its other points of interest.



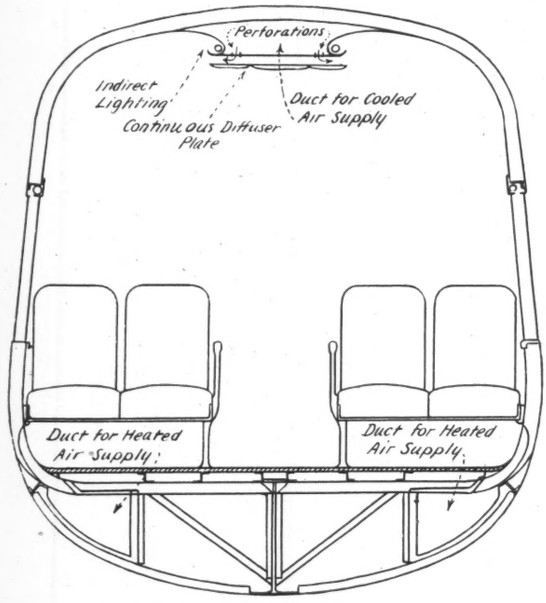
The new high-speed, stream-lined, air-conditioned train recently completed at the works of the Pullman Car & Manufacturing Corporation for the Union Pacific System, on the tracks at the builder's plant. Air for cooling the radiators of the 600-hp, 12-cylinder, distillate-burning engine is taken in through the grille work shown in the nose of the train. This air, forced into the engine room by fans, is controlled by an internal shutter arrangement, and after passing through the engine radiators, part is exhausted through the roof and part used for heating the train

auxiliary generator for battery charging, which also provides current for one of the two air compressors (the other compressor receiving its power from the main generator), for lighting and buffet refrigeration, and for air conditioning. A 7½-kw engine-generator set in the baggage compartment provides current for lighting, buffet refrigeration, and heating when the main engine is shut down for long periods.

"Cruising" speed of the train is 90 mph, and top speed (under favorable conditions) is expected to be 110 mph. In addition to the high speed, the elimination of the need of changing locomotives, less time required in servicing, etc., will enable shortening present schedules. For example, a present 60-hour run could be shortened to 38 hours, it is estimated, 5 hours of the time saved being due to less time required at stops. The fuel tank has capacity for a 1200-mile run.

Ducts Integral With Car Structure

Three continuous ducts, each an integral part of the train construction, run the length of the two passenger-car sections. In the second car, the ducts are baffled to assure even distribution of air to the outlets throughout the train. As shown in the cross-section reproduced here, there is one ceiling duct and two floor ducts, one on each side. There is an outlet at each seat for heated air from the floor ducts, the ceiling duct serving as a return. The outlets have adjustable dampers which enabled balancing the air supply when the train was tested. When cooling, the air circulation is reversed by means of motorized dampers, and cooled air is introduced against a diffuser plate into the passenger areas from perforations in the entire length of the ceiling duct, and returned to the conditioning apparatus through the two floor ducts. The air circulation obtained in this way



Cross-section of the U. P. train showing the three insulated air ducts which are an integral part of the train construction. For heating the two floor ducts are supply and the ceiling duct is exhaust; for cooling this scheme of air circulation is reversed. The bottoms of the cars are but 9½ in. over the rails and the tops only 11 ft, approximately 2 ft lower than conventional cars. Center of gravity is 38 in. above the rails, 20 in. lower than in the ordinary coach. Total width is 9 ft.

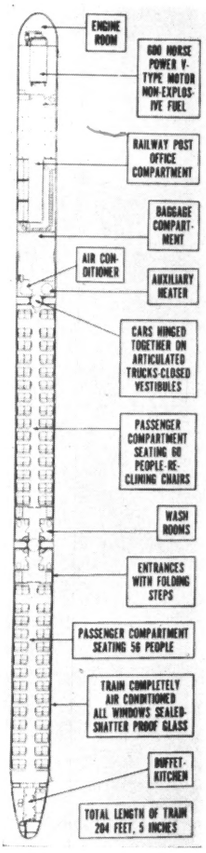
permits smoking to be allowed any place in the passenger sections, as each pair of seats may be said to have its own air supply and exhaust.

The air ducts have flexible connections between the articulated cars and are insulated with the same type of insulation used for the train itself. It will be seen from the cross-section sketch that the ceiling air duct forms an important part of the structure of the train, acting as a compression member. It also contains the lights for the indirect lighting of the cars.

The compact but complete buffet kitchen in the rear of the third car is separated from the passenger section by a bulkhead. A canopy and exhaust fan over the grill prevent cooking odors from reaching the car.

Method of Heating the Train

When heated air is being supplied to the train, the two floor-line ducts are supply and the ceiling duct is exhaust, as mentioned. Air for cooling the main engine of the train is taken through the grille work in the train


ENGINE ROOM
600 HORSE POWER V-TYPE MOTOR NON-EXPLOSIVE FUEL
RAILWAY POST OFFICE COMPARTMENT
BAGGAGE COMPARTMENT
AIR CONDITIONER
AUXILIARY HEATER
CARS HINGED TOGETHER ON ARTICULATED TRUCKS-CLOSED VESTIBULES
PASSENGER COMPARTMENT SEATING 60 PEOPLE-RECLINING CHAIRS
WASH ROOMS
ENTRANCES WITH FOLDING STEPS
PASSENGER COMPARTMENT SEATING 56 PEOPLE
TRAIN COMPLETELY AIR CONDITIONED ALL WINDOWS SEALED-SHATTER PROOF GLASS
BUFFET-KITCHEN
TOTAL LENGTH OF TRAIN 204 FEET, 5 INCHES

Sketch of the new U. P. three-car articulated train; its weight is about 85 tons, approximately the weight of a single modern Pullman sleeping car. The train has a total length of 204 ft-5 in. The power, mail, and baggage car is 72 ft-8 in. long; the second car 59 ft-10 in.; the third car, 71 ft-11 in.

nose and forced by two fans through the engine and the engine radiators. A portion of this air is then conveyed by a duct running through the mail compartment of the train to the two compartments in the baggage section which contain the heating and air-conditioning equipment, thus utilizing waste heat from the engine radiators to help heat the cars. A damper in this duct is controlled by a thermostat in the second car.

To provide for additional heating of the air which has passed through the engine radiators, and to heat the train when the main engine is not in operation, there are two oil-fired warm-air furnaces installed in the baggage compartment, one on each side for supplying heated air to the respective floor-line ducts. These heaters each have a normal capacity of 135,000 Btu per hr (maximum, 150,000 Btu per hr) with 1250 cfm of air. Each unit consists (in addition to the oil-burning equipment) of a combustion chamber, heat-transfer surface, a smoke hood with stack switch, and a stack with draft-adjusting equipment. The products of combustion pass out of the train at the rear of the first car.

The oil burner used is of the gun type with electric ignition; it has a direct-connected fan and pump and burns the same distillate oil as is used for the main engine of the train at pressures of from 80 to 160 lb per sq in., controlled by an adjustable pressure-regulating valve. The burners operate with a-c or d-c current. Weight of each complete unit is 580 lb and over-all dimensions are 38-in. length, 19-in. width, and 40-in. height.

By using two units (instead of one large unit) the duct construction was simplified, as otherwise a connection between the two floor-line ducts would be necessary.

There is a 1250-cfm heater fan of the blower type for each of the two floor-line ducts, operating at a 3-in. static pressure. Each of these fans is driven by a 1½-hp d-c direct-connected motor. Air is returned from the passenger sections through the ceiling duct.

For heating the mail compartment, there are two ducts running forward from the air-conditioning equipment compartment, one on each side of the train. A damper in each of these ducts is controlled by a thermostat located in the mail compartment. This compartment is not cooled.

The central control panel for the heating and air-conditioning systems which is located in the baggage compartment near the equipment. Reading from left to right, the switches are for Cooling Fan No. 2, Oil Burner No. 2, Oil Burner No. 1 and Cooling Fan No. 1

Operation of System When Cooling

A 7½-ton, 4-cylinder freon compressor, directly driven by a 12-hp d-c motor taking current from the auxiliary generator, supplies refrigeration for cooling the train. It is interesting to note that this 7½-ton capacity is sufficient for the entire train, as compared with a 5½- to 6-ton compressor as is needed for one ordinary Pullman car. This compressor is installed in the baggage section of the train with the other heating and air-conditioning apparatus, and the direct-expansion coil.

When cooling, the damper in the duct conveying air to the oil-fired heaters from the engine radiators is automatically closed and fresh air is taken in through two short ducts running from the conditioning compartments to the rear end of the first car. This fresh air is filtered through cleanable wire-mesh air filters, 4 in. thick, the wire mesh being coated with a special oil.

For forcing the cooled air to the cars, there are two blower-type fans (one in each of the compartments) rated at 1250 cfm and 2¼ in. static pressure. When cooling, the two heater fans are out of operation, and when heating, the two cooling fans are dead. These cooling fans are driven by 1½-hp d-c motors through V-belts and supply cooled air to the central ceiling duct. Air is returned to the air-conditioning compartments through the two floor-line ducts.

Control of Heating and Air Conditioning

Two thermostats for heating control are installed one on each side of the second car of the train and each controlling the operation of the oil burner for its side. Each thermostat has three mercury-tube contacts for high, low, and medium operation. An additional tube in one of the thermostats controls the motorized dampers which admit heat from the train power-plant cooling system. The temperatures in the third car of the train and in the mail compartment of the first car are controlled in similar manner. All of the thermostats operate through relays which are mounted on a control panel located in the baggage compartment near the heating and conditioning equipment.

A thermostat functioning in like manner controls the compressor for air cooling; it is located in the second car on a side wall.

There's not much in common between this Union Pacific train of another day, and the stream-lined, highly-polished "No. M-10000"

Smoke Abatement Saves Hudson County, N. J., Fuel Users $531,000 in Three Years

OVER half a million dollars has been saved by Hudson County, N. J., fuel users as a direct result of smoke-abatement activities, according to William G. Christy, Chief Smoke Abatement Engineer of the Department of Smoke Regulation of the County. In 1933 the saving amounted to $224,000, in 1932 it was $187,000 and in 1931 (first year of smoke-abatement work) $120,000, a total of $531,000 for the three years. These figures represent the cost of fuel that it would have been necessary to burn if smoke had continued at the same rate it did before the prevention program was inaugurated.

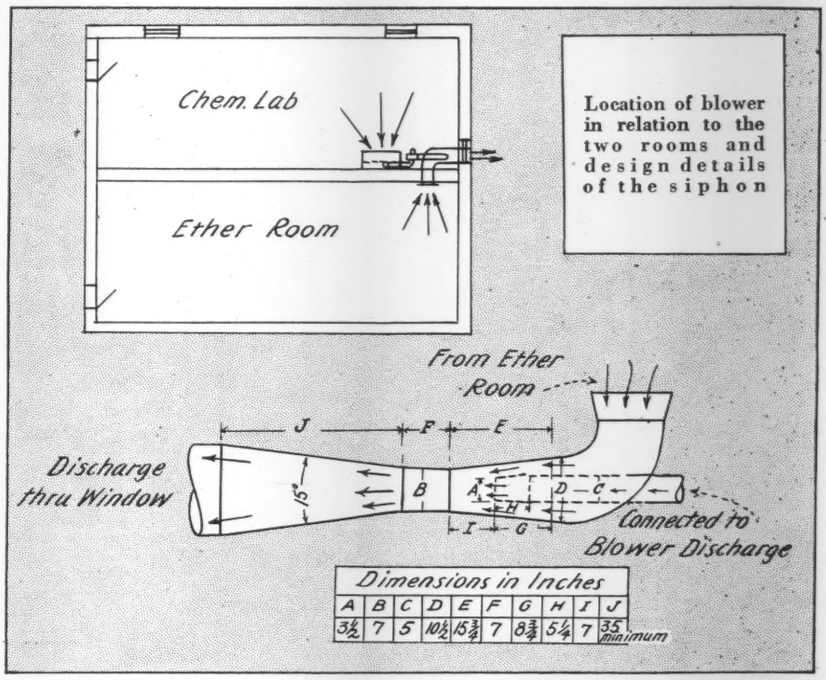
Insufficient combustion space is the source of smoke, says Mr. Christy, and it is this source that the smoke department attacks to achieve permanent smoke abatement. During the past three years, every new stoker, oil burner, or other new part of fuel-burning equipment in Hudson County has had to be okayed by smoke department engineers and a permit issued before operation could begin. Cooperation of fuel users in abating smoke is attributed mainly to the fact that they are "sold on the idea that they save fuel in proportion to the smoke that they abate, and have found in practice that it is true." Of 17,049 observations of industrial plants made in 1933, there were only 396 violations, a reduction since May, 1931, of 91 per cent in violations.

In addition to the reduction of smoke from locomotives—accomplished with the cooperation of the *Railroad Smoke Association,* composed of representatives of the nine trunk lines operating in the County—and that from floating equipment in New York harbor—with the cooperation of the *Marine Smoke Association* — Mr. Christy states:

"Heating plants burning bituminous coal have changed to anthracite coal or coke. A number have installed oil burners or stokers. In the case of industrial plants, improvement is due to a number of causes. Many have changed from high- to low-volatile coal. Hand-fired plants are using more careful firing methods. A number of boilers have been equipped with steam-air jets; also, many plants have installed oil burners or stokers.

"During the year 1933, 62 boilers were equipped with steam-air jets. This includes marine boilers and locomotives as well as industrial plants. Approximately 600 oil burners and 35 stokers were installed, including heating plants and industrial boiler plants. Several plants were equipped with smoke indicators."

Hospital Gets Economical Ventilation by the Siphon Method


Chem. Lab
Ether Room
From Ether Room
Discharge thru Window
Connected to Blower Discharge
Location of blower in relation to the two rooms and design details of the siphon
Dimensions in Inches
A B C D E F G H I J
3½ 7 5 10½ 15¾ 7 8¾ 5¼ 7 35 minimum

One Fan Does the Work of Two

By **Milton K. Arenberg***

WHEN remodeling a floor of the research laboratory building at a large Chicago hospital, the problem of ventilating two rooms from a budget allowance barely enough to cover the cost of one was confronted. One room has a large chemical hood and the other is used for research in which ether is used. Any ventilating equipment placed in the ether room would require an explosion-proof motor.

As the relative locations of these rooms on the floor was of no importance it was decided to build them adjoining each other, using one siphon system of ventilation for the two, as shown in the drawing. A pull-chain type of motor-starting switch located in the room with the blower and a cord leading through the wall allows starting the motor from either room.

A high-velocity-discharge type of blower with a 1720-rpm direct-connected motor was mounted on a shelf bracket from the wall in the room with the chemical hood; the inlet was connected to a chamber in the top of the hood. An insulation-board partition was erected to form a 2-in. air space or duct at the back of the hood for its entire width and extending to within 2 in. of the bottom so that the heavy acid fumes could be drawn off at the base or table of the hood. The blower was located far enough away from the window through which the fumes are exhausted so that the ether-room siphon could be installed and still be so located that, when the blower is not operating, no ether fumes can get into the blower or motor. The siphon was built according to the dimensions and design shown in the sketch.

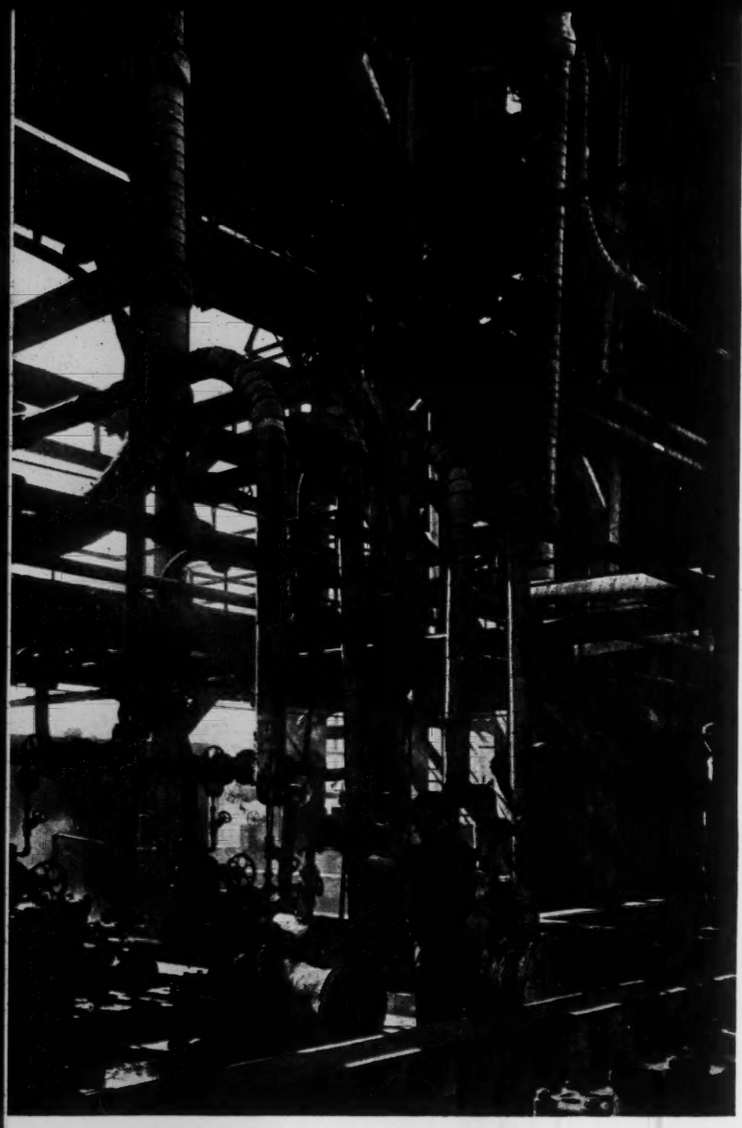
A recent test showed the blower to be exhausting 420 cfm from the hood and 790 cfm through the siphon from the ether room.

The building and installing of the sheet-metal work of the siphon represented the cost of ventilation for the ether room and when the simplicity and economy of the entire lay-out was presented to the hospital superintendent he readily agreed to the small increase necessary in the budget. The system has been operating successfully for the past two years.

Other Applications of Method

The method employed on this job has a number of applications in plants and buildings. The moving of air by a siphon has been successfully used for preventing the accumulation of paint on the blower wheel when exhausting paint-spray fumes; the elimination of water-cooled bearings when handling high-temperature gases; the protection of the blower wheel against corrosion when removing strong acid fumes; and for exhausting any material that would tend to clog in the blower wheel and housing.

*Chicago District Manager, Ilg Electric Ventilating Co.



Oil Piping Systems

for Production, Transmission and Refining of Petroleum

SECTION 3 of the new Code for Pressure Piping covers oil-piping systems used in the production, transmission, and refining of petroleum. Oil-piping systems in this connection are defined as embracing only oil-piping, refinery-gas piping, and piping for gasoline recovery plants; and as excluding steam and water lines, refrigeration piping, and gas and air piping incidental to operation of the petroleum equipment. The Code applies to piping, valves, and fittings up to the connections to drums and pressure vessels, but does not include the connections themselves. Oil lines are classified according to pressure and temperature. Oil vapor lines follow the same classifications and specifications as oil lines. Refinery-gas lines are specifically dealt with in separate paragraphs. Refining-gas lines in receiving houses, or within 50 ft of stills and other high temperature equipment, shall be constructed at least equal to *Class I* oil-piping requirements.

Requirements for Oil Piping

The requirements for oil-piping systems are so different from those of other Code sections that extensive abstracting is needed to present them intelligibly. On account of the variety of service conditions encountered in the oil industry, it was found expedient in drafting the Code to divide the oil requirements into eleven classifications set with reference to pressure-temperature limits. These classifications, together with the choice of materials, dimensional standards, and hydrostatic test prescribed for each, are summarized in Table 2. In the case of cast-iron pipe as well as wrought pipe, a further distinction is drawn between pipe located within refinery limits and that situated outside. The use of cast iron in hot-oil service is limited to temperatures not in excess of 400 F except where otherwise specified. For service conditions where pressures and temperatures vary from those given in Table 2, the use of cast carbon steel and cast chrome-nickel (or equivalent alloy) steel valves may be in accordance with the limitations given in Figs. 1 and 2. These charts present a system of adjusted pressure-temperature ratings for oil service similar to those for power piping described in the first installment of this series of articles (H. P. & A. C., September 1933, p. 457).

Materials for Oil Piping

The use of materials having physical and chemical properties equal or superior to the minimum requirements of the specifications listed in Table 1 is manda-

Table 1—Specifications for Materials

Material	Specifications
Cast iron	*A.S.T.M. A 126*
Cast carbon steel	*A.S.T.M. A 95*
Cast chrome-nickel steel	No spec. available
Forged steel	*A.S.T.M. A* 105 or *S.A.E. 1025*
Malleable iron	*M.S.S. SP-22*
Bronze and brass	
Bolts, alloy steel	*A.S.T.M. A 96*
Bolts, commercial steel	*A.S.T.M. A 107*
Bolts, wrought iron	*A.S.T.M. A 84*
Bolts, malleable iron	
Pipe, steel	*A.P.I. 5L* or *A.S.T.M. A 106*
Pipe, wrought iron	*A.P.I. 5L*
Pipe, open-hearth iron	*A.P.L. 5L*
Pipe, brass	*A.S.T.M. B 43*
Pipe, copper	*A.S.T.M. B 42*
Tubes, copper	*A.S.T.M. B 75, B 88*
Pipe, cast-iron, pit-cast	*A.S.T.M. A 44*
Pipe, cast-iron, centrifugally-cast or horizontally-cast in green-sand molds	*F.S.B. WW-P-421*

Note: Specifications referred to above are: *American Society for Testing Materials (A.S.T.M.); Society of Automotive Engineers, Inc. (S.A.E.); American Petroleum Institute (A.P.I.); Federal Specifications Board, U. S. Government (F.S.B.);* and *Manufacturer's Standardization Society of the Valve and Fittings Industry (M.S.S.).*

In all cases the latest revision is to be adhered to.

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This article continues the series on piping standardization, which started in the September, 1933, H. P. & A. C.

By
Sabin Crocker*

tory for the various classifications of oil service as indicated in Table 2.

Thickness of Wrought Pipe

For determining the minimum wall thickness of steel, wrought-iron, copper, and brass pipe on inspection prior to or at the time of installation, a Formula (6) ($t_m = PD/2S + C$) is provided for oil service similar to Formula (1) for power piping described in H. P. & A. C. for February, 1934, p. 55. The C and S values for all sections of the Code were summarized in Tables 4 and 5 of that article. Formula (6) is intended for computing the thickness of pipes in: (*a*) refinery service for temperatures not exceeding 750 F for steel or wrought iron, and 406 F for brass or copper pipe; (*b*) trunk pipe lines carrying cold oil. In the latter case the S values may be increased 40 per cent for pipes outside of refinery limits. These further provisos are made in the Oil Section regarding the thickness of pipe:

"For pipes both inside and outside of refinery limits it is recommended that no pipe lighter than standard weight shall be threaded. Regardless of the actual pressure the value P shall not to be taken at less than 100 lb gage for any conditions. For temperatures above 750 F, Formula (6) shall be used but only seamless-steel pipe or a high-temperature resisting alloy-steel pipe is permitted. The value of S used in Formula (6) for temperatures above 750 F shall be based on the best available information, with reference to creep stress determinations, for the material under consideration.

"It shall not be construed that the pipe thicknesses determined by the use of Formula (6) represent best engineering practice. The thickness of pipe so determined represents the minimum thickness on inspection at the time of installation allowable under any conditions. For thicknesses of cast-iron pipe see Pars. *306b*, *307b* and *307c* (reproduced later in this article). For design recommendations for pipe thicknesses see *Classes* I to II, inclusive (summarized here as Table 2)."

From the foregoing quotation it can be inferred that pipe-wall thicknesses computed by Formula (6) represent the very minimum allowable under any conditions, and that more conservative recommended practice is shown in Table 2. This spread between minimum requirements and recommended practice in the case of the Oil Section largely explains the relatively high S values for oil piping shown in Table 4 of the article in the February issue.

The decorative illustrations accompanying this article are typical views of the sort of piping covered by the Code

The first two of this series of articles on the new A. S. A. Code for Pressure Piping dealt with its history and purpose, and reviewed the section on Power Piping Systems. In connection with Power Piping an explanation was given last month of the formula for pipe-wall thickness, with a discussion of variations in this formula between Code sections. The present installment is devoted entirely to the section on Oil Piping, the requirements of which differ radically from those of other sections and involve a large number of service classifications. In reviewing the oil section, and others to follow in the April issue, attention is directed to practice which differs between services to suit the requirements of various industries.

Table 2—Summary of Requirements and Recommendations for Oil Piping Systems

Class and Max. Oil Service Conditions	Item	Screwed Fittings	Flanged Fittings	Valves	Pipe
Class 1[11] 125 lb 300 F	Material[2] Standard Test press.[6]	Cast iron[2] Mfrs. medium wt. 175 lb SSP {Up to 12 inch 300 lb {Above 12 inch 250 lb	Cast iron[2] A.S.A. B16 a,[5] 125 lb SSP 300 lb 250 lb	C.I. bodies and bonnets Mfrs. std. 125 lb SSP Bodies 300, disks 200 lb Bodies 250, disks 200 lb	Steel or wrought iron[2,3,4] A.P.I. 5L full wt line pipe See A.P.I. 5L
Class 2[11] 250 lb 406 F	Material Standard Test press.[6]	Cast iron A.S.A. B16d, 250 lb SSP 500 lb	Cast iron A.S.A. B16b, 250 lb SSP 500 lb	Cast iron Mfrs. extra heavy std. Bodies 500, disks 400 lb[7]	Steel or wrought iron[3,4] A.P.I. 5L full wt line pipe See A.P.I. 5L
Class 3[1,8b] 440 lb 300 F	Material Standard Test press.[6]	Cast or forged steel None available 750 lb	Cast or forged steel A.S.A. B16e, 300 lb SSP 750 lb	Cast or forged steel Mfrs. std. 300 lb SSP 750 lb	Steel or wrought iron[3] A.P.I. 5L line pipe[9] See A.P.I. 5L
Class 4[8] 585 lb 300 F	Material Standard Test press.[6]	Cast or forged steel Suitable for 400 lb SSP 1,000 lb	Cast or forged steel A.S.A. B16e, 400 lb SSP 1,000 lb	Cast or forged steel Mfrs. std. 400 lb SSP 1,000 lb	Steel or wrought iron[3] A.P.I. 5L line pipe[9,10] See A.P.I. 5L
Class 5[8] 150 lb 500 F	Material Standard Test press.[6]	Cast or forged steel[11] Suitable for 150 lb SSP 500 lb	Cast or forged steel[11] A.S.A. B16e, 150 lb SSP 500 lb	Cast or forged steel[11] Mfrs. std. 150 lb SSP Body 500 lb, seat 300 lb	Steel or wrought iron[3] A.P.I. 5L[12] See A.P.I. 5L
Class 6[8] 300 lb 750 F	Material Standard Test press.[6]	Cast or forged steel[11] Suitable for 300 lb SSP 750 lb	Cast or forged steel[11] A.S.A. B16e, 300 lb SSP 750 lb	Cast or forged steel[11] Mfrs. std. 300 lb SSP 750 lb	Steel or wrought iron[3] A.P.I. 5L[12] See A.P.I. 5L
Class 7[8] 400 lb 750 F	Material Standard Test press.[6]	Cast or forged steel Suitable for 400 lb SSP 1,000 lb	Cast or forged steel A.S.A. B16e, 400 lb SSP 1,000 lb	Cast or forged steel Mfrs. std. 400 lb, SSP 1,000 lb	Seamless steel Grade A "Extra strong" schedule See A.P.I. 5L
Class 8[8] 600 lb 900 F	Material Standard Test press.[6]	Cast or forged steel Suitable for 600 lb SSP 2,000 lb	Cast or forged steel A.S.A. B16e, 600 lb SSP 2,000 lb	Cast or forged steel Mfrs. std. 600 lb SSP 2,000 lb	Seamless steel Grade A "Extra strong," 8" & smaller See A.P.I. 5L
Class 9[8] 900 lb 950 F	Material Standard Test press.[6]	Alloy cast or forged steel Suitable for press.-temp. 3,000 lb	Alloy cast or forged steel A.S.A. B16e, 900 lb SSP 3,000 lb	Alloy cast or forged steel Mfrs. std. for press. & temp. 3,000 lb	Seamless steel, Grade A "Double extra strong" schedule See A.P.I. 5L
Class 10[8] 1500 lb 1350 lb 900 F 950 F	Material Standard Test press.[6]	Alloy cast or forged steel Suitable for press.-temp. 4,000 lb	Alloy cast or forged steel A.S.A. B16e, 1500 lb SSP 4,000 lb	Alloy cast or forged steel Mfrs. std., 1,500 lb & temp. 4,000 lb	Seamless steel, Grade A See note[13] 4,000 lb
Class 11 Trunk Pipe Lines Cold Oil High press.	Material Standard Test press.[6,15]	Cast iron or cast steel None available 1,500 lb	Cast iron or cast steel 800 lb hydr. or 600 lb SSP[14] 1,500 lb	Cast iron or cast steel Mfrs. std. to suit flanges[14] 1,500 lb	Steel or wrought iron[3,4] See Formula (6) See A.P.I. 5L

Thickness of Cast-Iron Pipe

Contrary to practice set up in other sections of the Code the thickness of cast-iron pipe is governed by empirical rules separate and distinct from the formula used for wrought pipe. The following paragraphs governing the use of cast-iron pipe inside and outside of refinery limits are quoted.

"Cast Iron Pipe Within Refinery Limits. (a) Cast-iron pipe may be used for:

(1) Oil or oil vapors where the temperature does not exceed 300 F and the pressure does not exceed 150 lb per sq in.

(2) Oil condensers or coolers where the pipe is covered by water, the temperature of which is not over 210 F, and where pressure of oil or oil vapor is not over 125 lb. The temperature of the oil vapor shall not exceed 525 F or the temperature of the oil shall not exceed 650 F. Where the piping is not immersed in a cooling medium, the specifications given in this Code for the particular pressures and temperatures shall apply.

Note: These temperature limitations are intended to be such that the temperature of the cast iron will not exceed 450 F.

(3) Gas lines where the conditions do not exceed 300 F and 50 lb pressure, or 200 F and 100 lb pressure.

"(b) Cast-iron pipe, when used for gas or oil piping within refinery limits, shall have the following actual minimum thicknesses at the time of installation.

Notes—Table 2

[1]Where corrosion conditions are severe, "extra strong" pipe or corrosion-resisting alloy-steel pipe of suitable strength instead of "standard weight" pipe, and heavier valves and fittings, or valves and fittings of a corrosion-resisting alloy of suitable strength are recommended.

[2]Brass (or bronze) valves, fittings, and pipe of equivalent strength may be used where a fire hazard is not involved.

[3]Steel pipe over 2-inch size shall be open-hearth lap-welded Class 1; 2-inch, bessemer lap-welded or open-hearth lap-welded Class 1; smaller than 2-inch, bessemer butt-welded or open-hearth butt-welded Class 1. Wrought-iron pipe in accordance with *A.P.I. 5L* may be substituted for steel in this class.

[4]Cast-iron pipe may be used under the limitations prescribed in the text of this section of the Code.

[5]Flanges used on pipe bends subject to expansion strains shall not be lighter than 250-lb SSP (steam service pressure) cast iron or 150-lb SSP steel.

[6]Hydrostatic test pressures in lb per sq in. gage.

[7]Disks shall also be given a 100-lb air pressure test.

[8](a) Where corrosion conditions are severe, heavier materials or corrosion-resisting alloys of suitable strength are recommended.

(b) For service conditions where pressures and temperatures vary from the ratings of the various Classes, the use of carbon cast steel, and cast chrome-nickel (or equivalent alloy) steel valves and fittings may be in accordance with the limitations given in the charts of Figs. 1 and 2.

[9]Same as Class 1 for sizes up to and including 10-in, *viz.* "standard-weight" line pipe using heaviest weight where more than one weight of any size pipe is shown in schedule. For 12-inch size use pipe having thickness equivalent to "extra strong" lap-welded pipe for pressures above 350 lb.

[10]For sizes up to and including 4-inch follow note.[3] For sizes above 4-inch and including 10-inch, use "extra strong" lap-welded pipe. For the 12-in size "extra strong" lap-welded pipe may be used up to 500-lb pressure. Seamless pipe, Grade A, with line pipe dimensions is also satisfactory for all sizes up to and including 10-inch. For the 12-inch size, seamless pipe, Grade B, is satisfactory.

[11]Malleable iron may be used up to 400 F and 250-lb pressure for this Class.

[12]"Extra strong" line pipe is recommended. "Standard weight" may be used up to 450 F.

[13]"Double extra strong" for sizes up to and including 1½-inch. For sizes over 1½-inch the actual thickness shall not be less than given by Lamé's formula using a fiber stress of 4,000 lb per sq inch, and dividing the computed thickness by 0.875 to allow for mill tolerance.

[14]For cast iron, *A.S.A.B16 bl* up to 800-lb pressure; none available for cast iron over 800 lb. For cast steel, *A.S.A. B16e* for 600-lb SSP.

[15]Material shall be suitable for a hydrostatic test pressure not less than 1½ times the service pressure for conditions outside of refinery limits.

(1) When cast vertically in dry-sand molds:

Service Pressure up to 50 lb	Thickness as specified in *A.S.T.M. A 44* for Class B
50 to 100 lb	Thickness as specified in *A.S.T.M. A 44* for Class C
100 to 150 lb	Thickness as specified in *A.S.T.M. A 44* for Class D

(2) When centrifugally or horizontally cast:

Service Pressure 100 lb or less (Sizes 4 in. to 24 in., inclusive)	Actual thickness shall not be less than as specified in *F.S.B. WW-P-421*, Class 150
Service Pressure 100 lb to 150 lb (Sizes 4 in. to 24 in., inclusive)	*F.S.B. WW-P-421*, Class 250

"**(c)** Cast-iron pipe, when used for gas or oil piping systems within refinery limits, shall be capable of withstanding a minimum hydrostatic test pressure of three times the service pressure for which the line is designed or under which it will operate, and in no case less than 300 lb."

"**Cast-Iron Pipe Outside Refinery Limits. (a)** Cast-iron pipe may be used for oil-piping systems outside of refinery limits where the temperature does not exceed 300 F.

"**(b)** Cast-iron pipe, when used for oil-piping systems outside of refinery limits, shall have the following minimum thicknesses at the time of installation.

(1) When cast vertically in dry-sand molds, not less than that specified in *A.S.T.M. A 44* for the class of pipe corresponding to the pressure as given in *Table 11* of that specification.

(2) When centrifugally or horizontally cast, in sizes 4 in. to 24 in., inclusive, not less than Class 150 thickness in *F.S.B. WW-P-421*.

"**(c)** Cast-iron pipe when used for oil-piping systems outside of refinery limits shall be subject to the following pressure and thickness limitations at the time of installation.

(1) When cast vertically in dry-sand molds it shall not be used for pressures greater than the allowable service pressure, for the various classes, given in *Table 11* of *A.S.T.M. A 44*.

(2) When centrifugally or horizontally cast the minimum metal thickness shall be as allowed in *F.S.B. WW-P-421* for the corresponding service tabulated therein. It may be used for higher service pressures than tabulated in *F.S.B. WW-P-421* provided the metal thicknesses are not less than allowed by Formula (6) given in *Par. 325* of this Section of the Code, when P equals the service pressure in lb per sq in. plus an allowance for water-hammer given in *Table 12* (see Table 3 of H. P. & A. C. February article), S equals 8,400 lb per sq in., C equals 0.14 inch, the minimum tensile strength of the material is 30,000 lb per sq in., and the pipe is capable of withstanding a hydrostatic test of four times the working pressure.

(3) In addition to the above limitations, the cast-iron pipe lines shall, when installed, be suitable for a hydrostatic pressure of not less than twice the service pressure for which the pipe line is designed and in no case less than 150 lb per sq in. test pressure. The test pressure shall be as designated in the *A.S.T.M.* and *Federal Specifications Board* specifications referred to above for the various classes and weights of pipe.

"**(d)** All cast-iron pipe above ground shall have either bolted flange connections, threaded joints, sleeve or gland couplings, or gland-packed joints made integral with the pipe, or special joints such as rubber or flexible rings held tight by pressure and properly retained. Bell and spigot pipe is permitted for underground gas lines."

[Mr. Crocker's next article will continue this discussion of the oil section of the new code for pressure piping, including valves; joints, flanges, and fittings; and miscellaneous requirements (thermal expansion, pipe covering, inspection and tests, etc.).

Following this, gas and air piping, district-heating piping, fabrication details, welding, etc., will be dealt with.—EDITOR.]

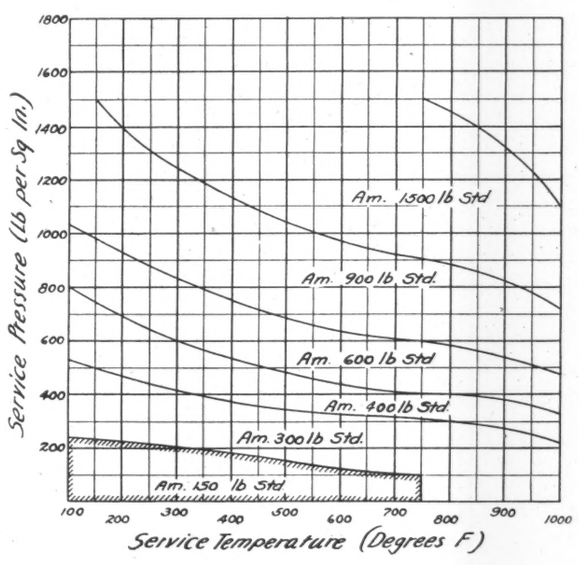


Fig. 1—Service oil pressure ratings for carbon-steel valves and fittings

Note: The area bounded by two adjacent curves specifies the American standard permissible for any particular service pressure and temperature condition located within it, *i.e.*, for a service pressure of 700 lb per sq in. at 550 F, Am. 900-lb Std. should be used.

This chart is based on the use of alloy-steel bolting material equivalent to *A.S.T.M. Specification A-96*.

These curves are tentative and subject to revision.

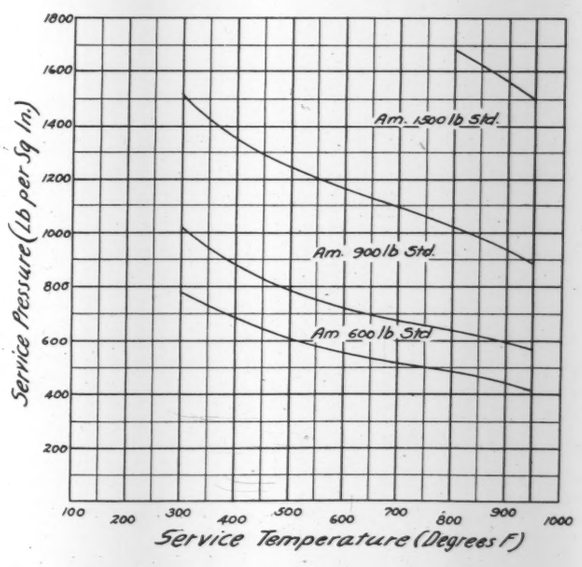


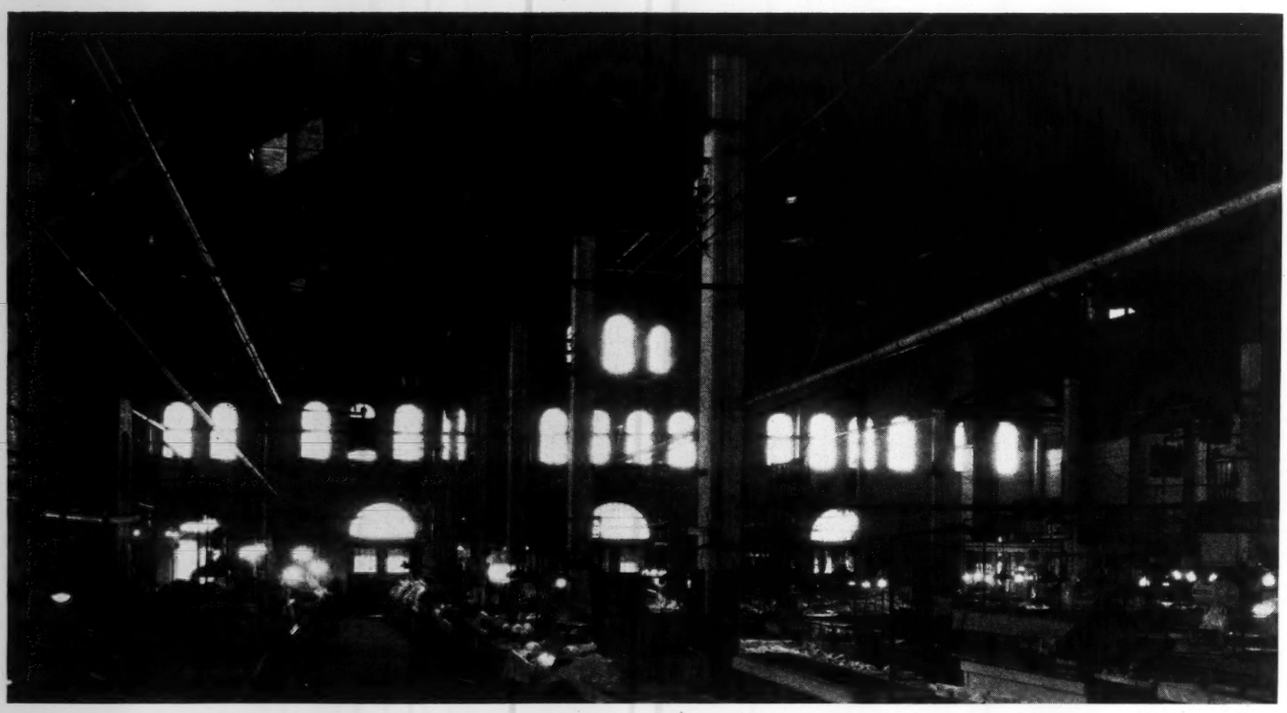
Fig. 2—Service oil pressure ratings for chrome-nickel or equivalent alloy-steel valves and fittings

Note: The area bounded by two adjacent curves specifies the American standard permissible for any particular service pressure and temperature condition located within it, *i.e.*, for a service pressure of 700 lb per sq in. at 550 F, Am. 600-lb Std. should be used.

This chart is intended to apply to valves and fittings made of chrome-nickel or equivalent alloy steel, having a minimum yield point of 65,000 lb per sq in. The curves are also based on the use of alloy-steel bolting material equivalent to *A.S.T.M. Specification A-96, Class C*.

For the American 900-lb and 1500-lb Standards, this chart is limited to pipe sizes 6 in. or smaller.

These curves are tentative and subject to revision.



The Central Market House in York, Pa., in which a unit-heater system was installed. Formerly unheated, the heating system was installed to induce buyers to stay longer, purchase more

Automatic Control System *for* 15 Unit Heaters

By **K. E. Rockhold***

A UNIT-HEATER system with an automatic control system which greatly simplifies operation was recently installed in the Central Market House, York, Pa. This market house, built some fifty years ago, had never been heated; feeling that a warm market house would induce purchasers to stay longer and buy more, the board of directors decided that it would be good business to provide a heating system.

Fourteen Units Supply 3,000,000 Btu per Hr

The building is "L"-shaped, with entrances on Beaver St. and W. Philadelphia St., and has an area of approximately 40,000 sq ft. The roof trusses are of wood and the peak of the building is 60 ft from the floor in the center. The sides are 18 ft high.

Heating computations were made for an indoor temperature of 60 F with 10 F outdoors, a temperature rise of 50 F. The side walls were computed with a conductivity factor of 0.30 Btu per hr per sq ft per F, the glass with a conductivity factor of 1.10, both with a temperature difference of 50 F. The roof, which is of 1-in. sheathing covered with slate, was computed with a factor of 0.35 and a temperature difference of 80 F, or 30 F higher than the floor. The air change was assumed to be once in two hours.

The total heat loss is 3,000,000 Btu per hr. In order to supply this heat fourteen unit heaters each with a capacity of 220,000 Btu per hr were installed. One unit rated at 300 sq ft of radiation was installed in the women's rest room.

The 4-in. steam service from the street mains of the York Steam Heating Company enters from the Beaver St. side of the building, rises along the wall and is connected to an 8-in. header through a 4-in. reducing valve. The header has two 5-in. connections to branch mains with a motor-operated valve on each. The branches extend down two sides of the building where the unit heaters are located. The return mains are supported under the steam supply and slope back to one corner of the building, where they are vented and, after passing through cooling radiators, are metered and discharged to an open sink and thence to the sewer.

Control System for the Units

The most important feature of this installation is the automatic control. The temperature is controlled by five thermostats, four of which are located in the main

*Mechanical Engineer, Careva Company, York, Pa.

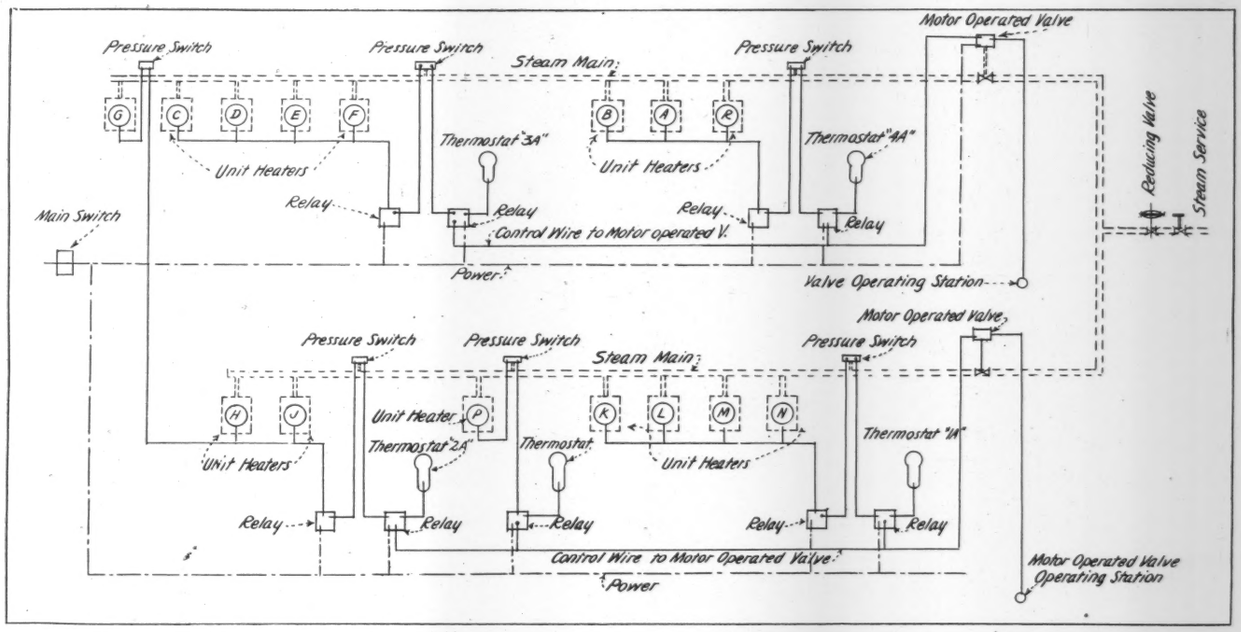


Diagram of the control system for the fifteen unit heaters. Steam is supplied from street mains and reduced to the proper pressure. Operating cycle of the control system is explained in the text

market room and one in the women's rest room. Thermostat No. *1A* controls four units, thermostat No. *2A* controls three units, thermostat No. *3A* controls four units, thermostat No. *4A* controls three units, and thermostat No. *5A* controls the unit in the rest room.

When any thermostat calls for heat, it first opens the motor-operated valve on the main supplying that group of units. The units do not start operating until the pressure in the main is 3 lb; this is controlled by a pressure switch connected to the relay that controls the units. Other units are cut in as heat is required by the thermostat controlling that group of units. When the temperature at any thermostat has risen to 60 F, that group of units is cut out by the respective thermostat. When the last thermostat is satisfied, the motor-operated valve is closed and remains closed until one of the thermostats again calls for heat.

The cycle of operation is as follows:

1. Any thermostat calls for heat.
2. One of the motor-operated valves opens.
3. When pressure in main is 3 lb, the pressure switch closes, which starts units in group controlled by the thermostat which requires heat.
4. When any thermostat is satisfied, the units controlled by it are stopped.
5. When the last thermostat is satisfied, the motor-operated valve is closed.

The system is operated by the market master entirely by the main service valve and the main switch. On days that the market is open, the main switch is thrown on and the main valve turned on. The building then heats up to 60 F, the units stop, and the motor-operated valve is closed. When the temperature drops to 55 F in any section of the building, the thermostat controlling that section starts its group of units.

No other attention is required until the market is closed, when the steam is shut off and the electric current is disconnected. It is not necessary to operate the main electric switch, as when the main steam valve is shut off, there is no pressure in the main and of course the units will not operate. The motor-operated valve has an independent station for controlling it independently of the automatic system.

Air Conditioning "Pays Its Way" in Candy Stores, Mrs. Snyder Finds

FROM present indications, the summer of 1934 will see many retail stores and shops employing the business advantages of air conditioning. What air conditioning has meant to the candy shops mentioned in the letter quoted below is equally applicable to many other types of retail establishments. This letter was written by Mrs. Snyder, who operates thirteen shops in Chicago and suburbs:

"Referring to my experience with our two air-conditioning installations in retail stores, you of course know that our candy is made with the advantages of air conditioning and that we couldn't produce the class of goods we do without it; our store experience, however, is new, and our reaction to its results may be of interest to you.

"During our hot June last year, our loss at the 71st Street store was as much as a ton of chocolates. The losses at the 20 S. Dearborn store were as heavy and were equalled in July. These losses were stopped entirely with the installation of air-conditioning units the 1st of July at 71st St. and August 1 at the Dearborn St. store.

"Air conditioning in any retail store is of advantage in drawing customers and in holding them in the store. In hot weather people seek out places where they can be comfortable, even if they expect to stay only a few minutes. In the case of a store handling practically any foodstuff or other perishable product, air conditioning will, as in my case, pay for itself in an exceedingly short time, and for years thereafter will produce dual profits—from prevention of deterioration of stock, and from increase in patronage. To this can be added the important benefit in comfort and health to the store personnel, and at no additional cost.

"I feel safe in predicting that air conditioning will soon be commonplace in up-to-date stores, and especially in those where the stock would otherwise be subject to spoilage or deterioration in the warm months."—MRS. SNYDER.

Water-Vapor Refrigeration—*Steam Jet*

By **Paul Bancel***

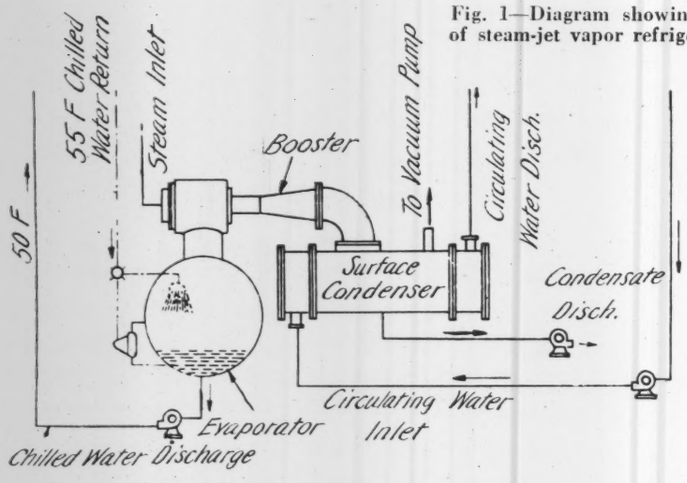


Fig. 1—Diagram showing operation of steam-jet vapor refrigeration unit

THE use of steam ejectors for compressing water vapor was suggested by Sir Charles Parsons about thirty years ago. In an early patent he states that his invention consists of employing vacuum intensifiers (boosters) of the steam-jet type, arranged to effect cooling by evaporation of water vapor from the body of the water to be cooled. Commercial development of Parsons' idea was probably delayed by the inefficiency of the boosters available; even as recently as five years ago steam consumption was relatively high and the back pressure attainable decidedly low, compared to present-day good design.

The Apparatus

Steam-jet refrigeration consists of apparatus shown diagrammatically in Fig. 1 in which the water vapor boiled off at low pressure is compressed by ejector action of a steam jet and discharged at a pressure high enough to permit condensation by water of ordinary temperature. It would be physically possible to compress vapors all the way to atmospheric pressure using a relatively enormous quantity of steam in successive boosters. This is unnecessary, however, because with either natural or artificial supplies of cooling water, it is possible to condense the steam at around 28 in. vacuum or 2 in. absolute pressure.

In addition to the steam-jet booster, the apparatus of Fig. 1 consists essentially of an evaporator and a condenser with auxiliary air pump. The water to be cooled is sprayed into the evaporator. If the water enters at 55 F and the absolute pressure within the evaporator is maintained at 0.36 in. of mercury, which corresponds to a boiling point of 50 F, then it is obvious that evaporation must take place until the water is cooled to 50 F. Tables of the properties of steam or water vapor show that the amount of evaporation is approximately one-half per cent to obtain 5-F cooling. The evaporation

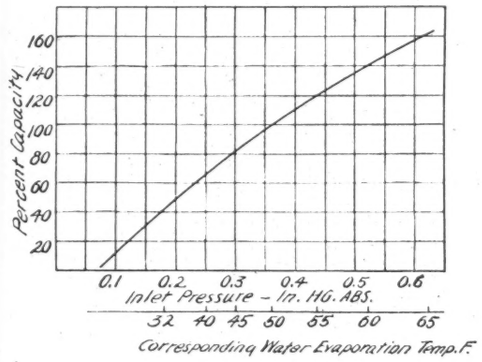


Fig. 2—Capacity characteristics, steam-jet booster

WATER is a decidedly non-volatile refrigerant; at mean atmospheric pressure it boils at 212 F and even at very high altitudes its boiling point is reduced only to about 160 F. To reach a boiling point of 50 F, it is necessary to reduce the pressure to 0.36 in. of mercury or a vacuum close to the barometer. Under these conditions the specific volume of water vapor is over 1700 cu ft per lb and a displacement of about 350 cfm is required per ton of refrigerating effect (200 Btu per minute).

The development of water vapor refrigeration has therefore depended upon the development of compressing units capable of "sweeping" very large volumes of low-density vapor. These have taken two forms, the steam-jet booster and the centrifugal compressor, the first of which is discussed here. Centrifugal water-vapor refrigeration will be considered in a second installment.

*Ingersoll-Rand Company, New York City. From a paper presented at the 26th annual meeting of the *American Institute of Chemical Engineers*, Dec. 13, 1933, Roanoke, Va.

loss is replaced by make-up water supplied from an outside source or by the return of condensate from the main condenser.

For each pound of water evaporated, about 3 lb of steam must be used in the booster jet and accordingly the total discharge of compressed steam and vapors amounts to about 4 lb. The foregoing figure for steam consumption is used for illustration only; the actual quantity of steam will vary widely with existing conditions.

The mixture is condensed by the condenser shown at the right, which is the third major part of the apparatus. This can be of either the surface, barometric or ejector type. The necessary pumps and air removal equipment are fitted as required for the particular service. The surface condenser is probably used most frequently.

The heart of the system is the steam-jet booster. Steam issues from the nozzles at velocities of 3500 to 4500 feet per second, draws in the cold vapors by aspiration and compresses the entire mass within the throat and diffuser of the ejector. Design is based largely on experiment; the proportions, size and arrangement of the essential parts have a vital influence on the capacity and compression range per pound of steam used. It is essential therefore that complete test facilities be available to the designer and, as boosters for steam-jet refrigeration may readily run into large sizes, the testing facilities are necessarily elaborate.

Economy of Steam-Jet Refrigeration

It is not the author's purpose to present tabulations of the annual expense with different types of refrigerating plants as in his experience such comparisons must embrace too many premises as to costs, local conditions, nature of load and service, to have any useful purpose. In general, with steam pressures of 100 lb or more a steam consumption of 25 to 30 lb per ton may be assumed. If steam is worth 25 cents to one dollar per thousand lb, ten lb are worth ¼ cent to a cent and the hourly cost of steam is on the order of ¾ of a cent to 3 cents per ton. A mechanical refrigeration unit may be assumed to require about one horsepower per ton, and if motor driven, a power input of less than a kilowatt. Depending on the cost of power, the hourly cost may again be anywhere from a fraction of a cent to 3 cents per ton.

If low-pressure steam is used the steam consumption of the boosters is considerably greater, but the steam less expensive. In any case, the total seasonal expense depends also on the nature of the load, the response of the unit to partial loads, the nature and cost of water supply, and the important elements of first cost and fixed charges, all of which are subjects for study in individual installations.

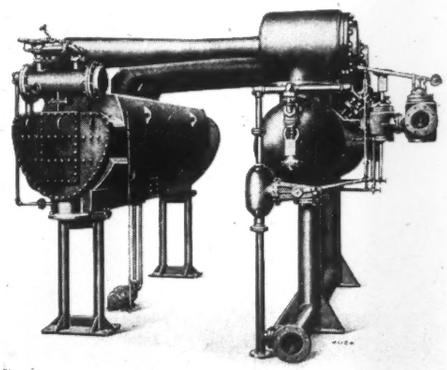


Fig. 3 — A 250-ton unit for an office-building air-conditioning plant

Operating Characteristics of Steam-Jet Boosters

The capacity of a given booster ejector, that is the lb of water vapor or other gas drawn in and compressed at fixed suction pressure, is approximately constant regardless of the amount of steam being used. This fact is usually hard to grasp; Fig. 2 shows a typical characteristic at normal steam flow; the capacity at 50 F for example is 100 tons. If now the steam pressure on the jets is raised 25 lb and the steam flow in proportion, the capacity at 50 F remains 100 tons. It should be emphasized that reference is made to a fixed booster which is operated with steam at different pressures, not to a series of boosters designed for the different pressures and steam flows. To save steam therefore under varying load conditions, multiple units may be used with hand or automatic control to shut off one or more boosters. An arrangement with four boosters is common in units of larger size.

Manifestly, with multiple boosters some provision must be made to prevent short circuiting of the vapors from the condenser through a non-operating jet and back to the evaporator. One solution is to use large isolating valves in the booster suctions; another to subdivide the evaporator into tight compartments. The latter design is shown in Fig. 4. All of the booster jets discharge in parallel to a single condenser, but each jet operates on its individual compartment in the evaporator. Each compartment is fitted with individual spray devices for the water to be chilled and with individual loop seal outlet pipes leading to the chilled water removal pump.

The evaporator compartment of any jet that is not in operation is at condenser pressure, but as this compartment is isolated, it does not affect the operation of the active jets. To turn on a jet, it is necessary to turn on the steam and open the corresponding water and vent valves. Fig. 3 shows the arrangement.

In the unit of Figs. 5 and 6 further improvements have been made, eliminating all but the steam valves. Opening or closing a steam valve automatically controls the water flow to the corresponding compartment. Fig. 5 explains the design. The water enters each compartment over weirs and when a booster is shut off the condenser pressure now exerted in the compartment depresses the water so that it cannot flow over the weir, but is trapped. Turning on a booster creates higher vacuum and draws the water up so that it sprays over the weir into the chamber.

Reserve Capacity of Steam-Jet Refrigeration

A steam-jet refrigerating unit has large reserve capacity, for small increase in chilled water temperature;

an increase to 55 F results in a tonnage of 120 per cent (Fig. 2). In general, there is a reserve of between 4 and 5 per cent per degree increase in temperature.

However, a refrigerating plant must not only cope with heavy tonnage demands but also excessive head or back pressures due to extremely hot circulating water. A river which shows an average maximum temperature of 85 F may at times heat up to 90 F, or a cooling tower designed for high wet-bulb temperature may nevertheless deliver water 5 F hotter than normal maximum under unprecedented weather conditions. Under such conditions of excess back pressure a steam-jet unit may fail to function entirely. This characteristic is inherent in the nature of compression by kinetic action.

If the condenser is designed for 85 F water and 2-in. back pressure an increase to 90 F would reduce the vacuum, or increase the back pressure to 2.3 in. With 0.36 evaporator pressure the ratio of compression demanded of the booster is thus increased from 5.5 to 6.35, which is beyond a commercial leeway of design. By this is meant that a manufacturer bidding originally with this amount of compression ratio in reserve, would find his steam consumption guarantees criticized and his design considered inferior.

The steam-jet booster will therefore break back; that is, it will be unable to compress its own burden or even a small quantity of vapor through the new and higher range of compression. This instability will continue until the evaporation pressure has increased by a relatively large amount and the chilled-water temperature is 10 or 20 F hotter.

Reserve against instability or failure of this type lies in an increase of steam pressure. As shown in Fig. 7, every increment in steam pressure results in a corresponding increase in back pressure against which the booster jet continues efficient operation. A typical example is given in the following table; an increase from 125 lb gage to 150 lb gage results in stable operation of the jets against a back pressure of 2.3 in. as against 2 in. The steam flow is increased about 17 per cent. The chilled water temperature may now be increased about 2½ F as shown in the last column for comparison with other types of refrigeration operating with hot condensing water temperature, but at normal load only. Under this condition the tonnage is increased by about 10 per cent.

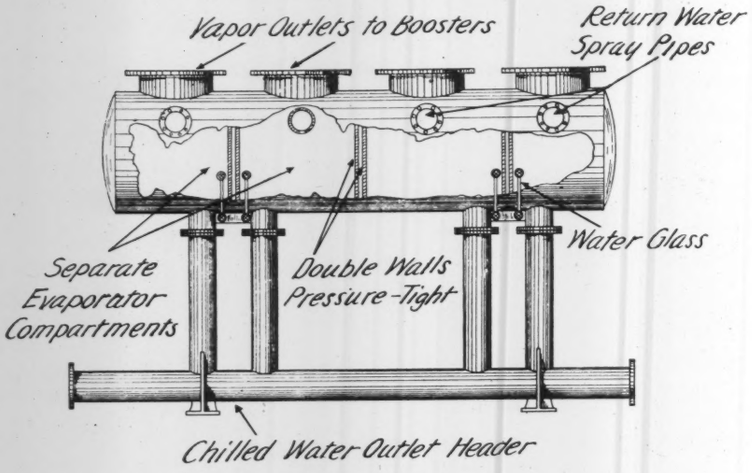


Fig. 4 (Above)—Evaporator, showing separate compartments for each of the boosters

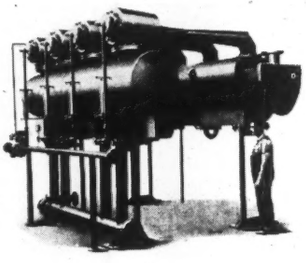
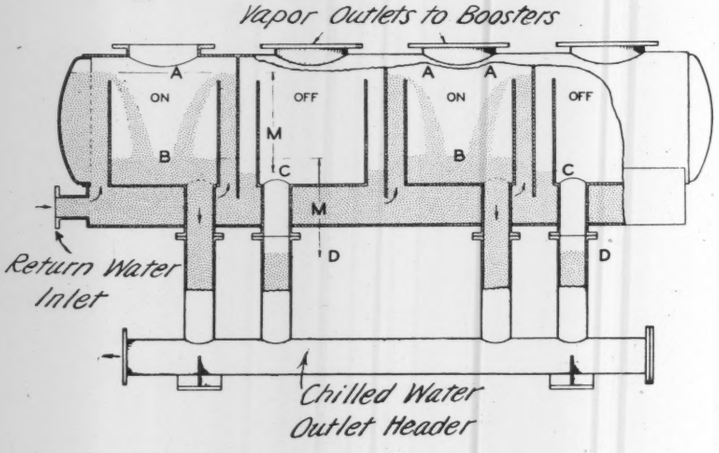


Fig. 6—A 100-ton refrigerating unit for a hotel air-conditioning installation

Fig. 5 (Below)—Arrangement of weir-type evaporator



A—Level of return water over weir of active section.
B—Level of chilled water in active section.
C—Level of return water below weir of inactive section.
D—Level of chilled water in outlet leg of inactive section.
M—Head of water equivalent to difference between evaporator vacuum and condenser vacuum

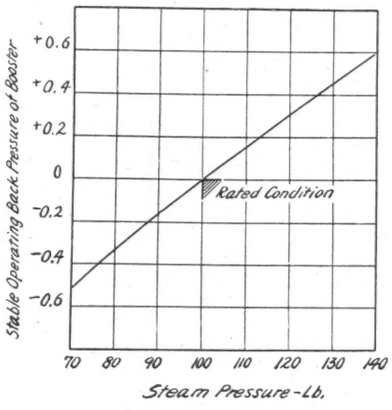


Fig. 7—Back-pressure characteristics, steam-jet booster

	Designed Max. Condensing Water Temp	Extreme Maximum Condensing Water Temperature	
Condensing Water Temp., F...	85	90	90
Back Pressure, in.....	2	2.3	2.3
Chilled Water Temp., F.....	50	50	52½
Steam Press., Lb Gage.....	125	150	150
Steam Flow (approx.).....	100	117	117
Tonnage	100%	100%	110%

The unit therefore has a very desirable characteristic of increased tonnage capacity under conditions of extremely hot condensing water and high back pressure which are most likely to coincide with heavy tonnage demands. However, the heat load has been increased by the added steam flow and also slightly by the added tonnage and the condenser therefore would not produce the back pressure of 2.3 in. unless it were designed to do so. A larger quantity of water so as to maintain the same temperature rise, and additional surface in the condenser as originally installed, would combine to take care of these peak conditions.

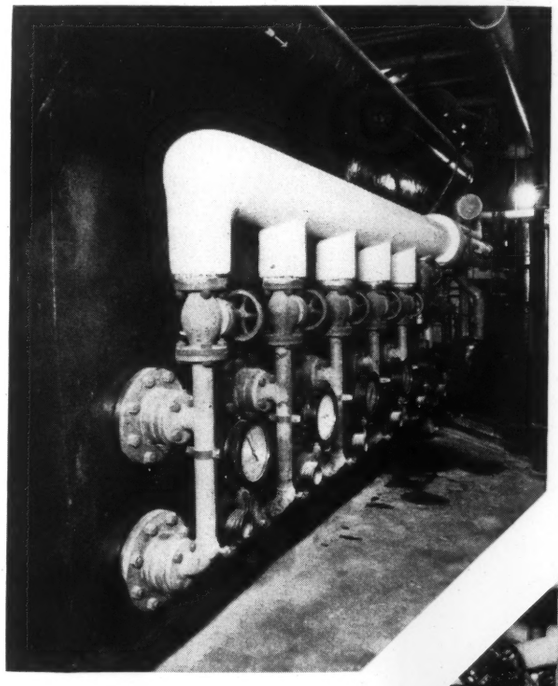
In some cases the additional tonnage may not be desired under the peak water conditions, or with cooling towers, it may not be desirable to supply sufficient capacity to cope with the added heat load. In such cases the heat quantity can be maintained at normal by shutting off one of the booster jets. In this way the added steam flow due to raising the steam pressure is off-set by deliberately closing part of the steam nozzles and the necessary tonnage load accommodated by increase in chilled-water temperature. As the overload capacity is great for a small increase in chilled water temperature, any standard sub-division of the boosters will usually be found sufficiently flexible for all the variations in operating conditions that may be encountered.

Summary

In summary, it is desirable to repeat the two important characteristics of steam-jet refrigeration:

First, there is an inherently large reserve tonnage capacity. Under such conditions the chilled-water temperature increases only a comparatively small amount.

Second, high condensing-water temperature must be counteracted by reserve steam pressure. Unless all extreme conditions can be safely predicted, the apparatus should be initially designed with a reserve of steam pressure. Under extreme conditions the steam pressure is raised, and at the same time if the added heat tends to overload the condensing water supply, the steam quantity is reduced by deliberately shutting down one of the boosters.

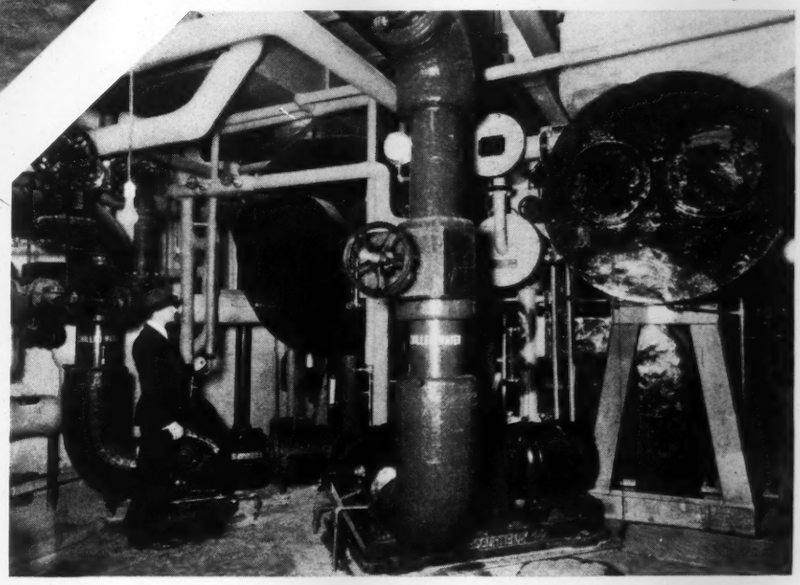


Steam-Jet Equipment at Rockefeller Center

By **André Merle***

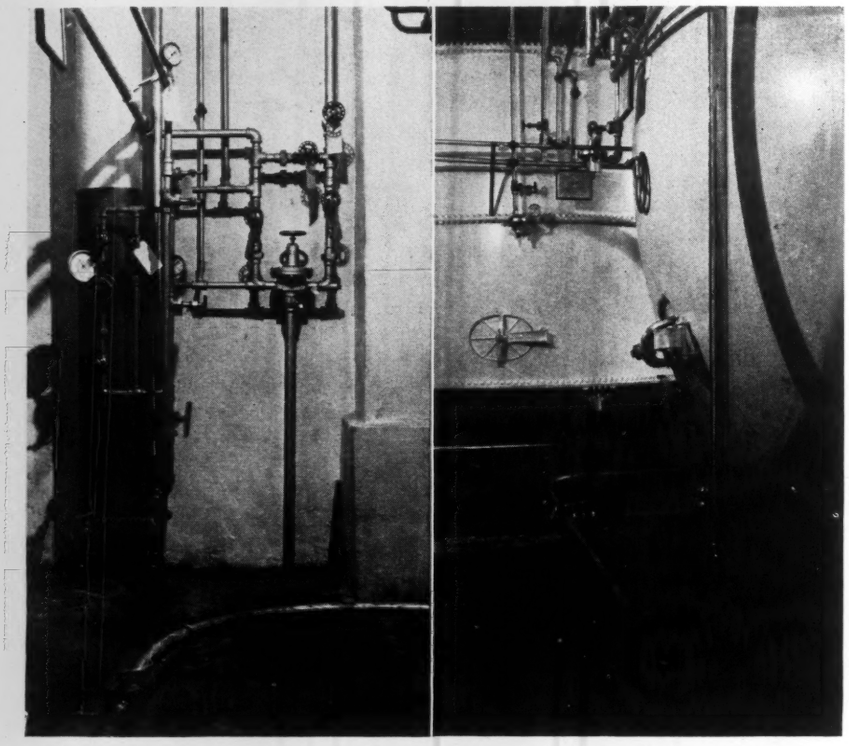
STEAM-jet refrigeration and its application to the cooling and air conditioning of buildings has been given considerable attention of late. To the British Empire Building and La Maison Francaise at Rockefeller Center belong the distinction of pioneering the largest steam-jet refrigeration systems for complete air conditioning. These units have a combined standard refrigerating capacity equivalent to 1,360,000 pounds of artificial ice, a quantity which exceeds the refrigerator (ice-box) requirements of a fairly large city of 180,000 inhabitants.

The first photos of the completed installation of steam-jet equipment in the British Empire Building are reproduced here. One of them shows Ernest Williams (chief engineer and office manager for Clyde R. Place, the consulting engineer) inspecting the operation of the 300-ton unit; the other shows the battery of steam boosters, which are served by street steam. The complete air-conditioning system in this building was described in an article in the May, 1933, issue.



*Air-Conditioning Engineer, Staff of Clyde R. Place, Consulting Engineer, New York City.

Left—The air-pressure regulating devices are shown here; the incoming beer line is shown at the floor. The beer is kept under the proper pressure by means of air to prevent it from foaming, and to force it up to the bottling department. Right—Valves and piping on the sides of the Government tanks. Note gage glass in foreground and pressure regulator



Piping *that's* Clean

is Brewery Requirement

By Daniel T. O'Neil*
and Waldemar Mortensen†
as told to
Francis A. Westbrook

. . new Government-cellar piping at Harvard Brewery has features of practical interest

WHEN the Harvard Brewery, Lowell, Mass., was reconditioned much of the old equipment was made to serve very satisfactorily, but when it came to the Government cellars, where the beer is stored in tanks prior to bottling, it was decided that entirely new piping installed according to modern practice would be necessary. The result has been a job with several features of practical interest. The first consideration in such piping is to provide a perfectly smooth, sanitary system free from pockets or recesses in which the beer might collect and sour. In this respect the conditions are similar to those governing the piping of milk, but with the difference that beer, being carbonated, must be handled under pressure. Government seals and locks must also be used with beer piping. This led to layout arrangements not found in most piping jobs.

The new pipe line from the stock house to the Government tanks is of tinned seamless copper tubing with recessed fittings; its outside diameter is 1¾ in. and its thickness No. 13 Stubbs gage. By maintaining the smooth interior surface by means of the recessed fittings and making only sweep turns of not less than 18-in. radius it is possible to clean the pipes with spherical brush balls forced through under water pressure. The tinned recessed joints are sweated into place and a Government seal is placed over them to guard against tampering. The means by which the brush balls are gotten out of the pipe is explained below.

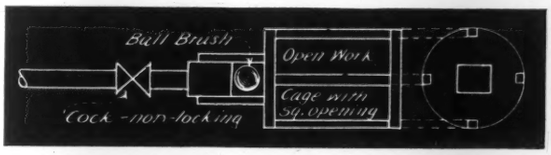
In the Government cellar there are three vertical cylindrical tanks of 100-barrel capacity and four horizontal cylindrical tanks of 150-barrel capacity. The pipe line from the stock room comes in through a tunnel and passes in front of all the tanks with long sweep bends, with connections at each tank for filling and emptying. A vertical line leads to the bottling department upstairs. The valves for filling and emptying may be locked; when a tank is to be filled the Government inspector locks the emptying valve and unlocks the filling valve. A long calibrated glass gage shows when the tank is full. When filled, the inspector locks the filling valve and unlocks the emptying valve. Connec-

*Engineer, Fred. Ophuls & Associates.
†Architect.

tion is then made to the pipe to the bottling department with a flexible hose.

How the Piping Is Cleaned

The fittings are designed especially for the purpose they have to serve. A sketch shows the fitting where the brush ball is ejected from the main pipe line; its design was suggested by the Government inspector and it is made so that it will not be necessary to lock its



The brush ball ejector fitting, which makes it unnecessary to have a locking cock. The opening from the cage is square and smooth, making it impossible to make any sort of a connection for drawing off beer

controlling cock. When this cock is opened for cleaning the ball brush may be ejected between the brass bars of the cage at the end. The opening from the cage is square and smooth to make it impossible to make any kind of a connection to draw off beer. Of course it is equally necessary to clean the fitting entering each tank. Consequently at each of these points there is a cross-piece with a locked cap which can be removed for cleaning. This cap is unlocked by the inspector when the tank is empty, and when the entering valve is unlocked, so that the whole may be cleaned with a wire brush.

The inlet and outlet valves for the beer at each tank are on the same piece of pipe to avoid too many holes in the tank; the valves are at an angle with each other. There is a cock at each end of the gage glass which can be closed in case the glass is broken. The caps for holding the glass at each end have Government locks making it impossible to draw off beer in this way.

The beer must be kept under proper pressure so that it will not foam, and to force it to flow upstairs to the bottling department. The beer is pumped from the stock tanks to the Government tanks by a motor-driven centrifugal beer pump. It must be pumped against pressure. This means that there must be an air line to keep up this pressure. The air-supply header is an ordinary 1-in. galvanized pipe. A constant pressure of 15 lb is maintained in this, which is the pressure in the beer tank. There is a relief valve set at 20 lb on the tank so that as it fills up with beer the air is allowed to escape, thus maintaining a constant pressure. When the tank is filled, the air is shut off. The pressure of the air-compressor receiver is 40 lb reduced to 15 lb by means of an ordinary reducing valve in the air line from the receiver of the compressor.

In the reverse process, when the beer is being drawn off, the air is turned on again. As the beer is drawn off, the total pressure is the head of beer in the tank plus the 15-lb air pressure. Consequently as the tank empties the net pressure would decrease if the air pressure were not correspondingly increased. This is accomplished by drawing the beer off through a pressure-compensating regulator, the diaphragm of which actuates a valve in the air-pressure compensating header. The diaphragm automatically opens a valve in the air compensating line and raises the pressure in the air supply header. This keeps the beer under constant pressure as is necessary in order to have the bottling machinery function properly.

FLOW AND PRESSURE-DROP Calculations for Process Piping

By Emory Kemler*

ON the next page is a chart designed to facilitate the making of pressure-drop calculations for liquids of various kinematic viscosities flowing in ½-in. pipe. The complete series is planned to cover standard pipe sizes from ¼ to 4 in., the viscosities being chosen to cover a range that will take care of any ordinary process fluid that is being piped.

The first two charts to be published appeared in the October, 1933, issue and were for 1-in. and 2-in. sizes. A chart for 1¼-in. pipe appeared in November, 1½-in. pipe in December, ¾-in. in January. An explanation of the charts and an example of their use also was published in October, as was a conversion chart for kinematic viscosity and viscosity in Saybolt seconds. Allowing for roughening and accumulations and turbulent flow were also discussed, and the following table showing how the pressure drop increases with increased amount of accumulations was given:

Per Cent Decrease of Diameter	Factor by which pressure Drop should be increased, per cent
1	5
2	10.5
3	16.5
4	22.5
5	29
6	36

This explanatory material in the October issue should be referred to in connection with use of the chart published this month.

*University of Pittsburgh, Pittsburgh, Pa.

Pipe Flow Chart for Liquids
¾" Std. Steel Pipe-0.622" Inside Dia.
Inside Surface Clean and Smooth
No Reduction of Diameter
Kinematic Viscosity Ft.-Lb. Sec. Units = μ/ρ
Velocity in Feet per Second
Loss of Head in Feet of Liquid
Pressure Drop in Pounds per Sq. In. per 1000 Ft. (Multiply by Specific Gravity)
Cubic Feet per Minute
Gallons per Minute
Barrels per Hour (42 Gals.)

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

1895

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Thermodynamic Properties of Moist Air

By **John A. Goff* *(NON-MEMBER)*, Urbana, Ill.**

THERMODYNAMICS finds an important application in the field of heating and ventilating. Here, as in the field of power generation, it investigates and defines the properties of the media employed and describes the various ways in which desired changes of state can be accomplished with particular reference to the energy quantities involved. In its application to heating and ventilating, thermodynamics has to deal with a medium, namely, atmospheric air, which is somewhat more complex than the media usually employed in power generation due to the fact that it is one of variable composition. It may be expected, therefore, that atmospheric air will be found to possess thermodynamic properties not found in the simple media of power generation.

The heating and ventilating engineer already possesses sufficient information, mostly in the form of psychrometric charts, to enable him to deal effectively with most problems in his field involving properties of atmospheric air. This being true, it may appear quite unnecessary to attempt a further contribution to the subject. Still, much of this information, although capable of yielding approximate results of practical value, is, in some cases, strictly speaking, incorrect and sometimes leads to impossible conclusions if used without discretion. Consequently, an attempt to work out a thermodynamically consistent treatment of the properties of atmospheric air based on best available thermal data, written in the language of thermodynamics, but yet reduced to a form which admits of quick and easy application, may possibly find favor with even the more practical-minded engineer. The present paper is such an attempt.

Dry Air

We begin with an important simplification. Thus, it will be recognized from the start that atmospheric air can be regarded as a mixture of only two constituents. The relative proportions of oxygen, nitrogen, carbon dioxide, etc., are either so small or subject to such small variations that they need not be considered separately. Instead, they may be treated collectively as components of a gas mixture of constant composition called, Dry Air. Dry air is one constituent of atmospheric air, and water is the other.

(1) *Composition.* For the sake of definiteness, the volume composition of dry air given in *International Critical Tables* (I,393) may be used as standard. It is

N_2	$= 0.7803$
O_2	$= 0.2099$
A	$= 0.0094$
CO_2	$= 0.0003$
H_2	$= 0.0001$
	1.0000

This volume composition is also a *mol* composition. Consequently, if each figure be multiplied by the molecular weight of the corresponding constituent and the resulting products added, their sum may be used as the molecular weight of dry air; thus, $m_a = 28.967$ (lb/mol).

(2) *Specific Volume.* Under the conditions of pressure and temperature ordinarily encountered in heating and ventilating, dry air may be assumed to behave like a perfect gas so that its specific volume, v_a (ft³/lb), may be related to its pressure, p_a (lb/ft²), and absolute temperature, T (F), by the well-known equation

$$v_a = \frac{B_a \times T}{p_a} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

in which $B_a = 1544/28.967 = 53.34$ (ft/F). Column 8, Table I, gives values of v_a for a pressure, $p_a = 30$ in. Hg.

(3) *Specific enthalpy.*[1] Within the same range of temperature and pressure for which Eq. (1) is valid, the specific heat-at-constant pressure of dry air is a function of its temperature only. Accordingly, its specific enthalpy can be calculated from

$$h_a = \int (c_p)_a \, dT + \text{const} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

in which the constant of integration can be chosen quite arbitrarily. For rough computations, $(c_p)_a$ is usually assigned the average value, 0.24 (Btu/lb F); but, for more accurate work, its actual variation with temperature should be taken into account. Column 5, Table I, gives values of h_a derived from specific heat data given in *International Critical Tables* (V, 81), the constant of integration having been adjusted to make all tabular values positive.

Water: Thermodynamic Properties

Although the moisture in atmospheric air is usually in the state of superheated vapor, sufficient cooling will always reduce it to a state of saturation. Consider, first of all, the thermodynamic properties of the saturated vapor.

Saturated Vapor

(1) *Vapor Pressure.* The pressure, p''_w of saturated water vapor is a function of the temperature only. The best experimental data on the relation between p''_w and t are probably those in *International Critical Tables* (III, 210-211). The actual vapor pressure is slightly affected by the presence of an indifferent gas such as dry air. Consequently, a correction easily estimated from formulae in *International Critical Tables* should be applied for the sake of accuracy.

(2) *Specific Volume.* The specific volume of saturated water vapor can also be calculated from the perfect-gas equation,

$$v''_w = \frac{B_w \times T}{p''_w} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

as in the case of dry air with this difference, however, that for

*Associate Professor of Thermodynamics, University of Illinois.

Presented at the 40th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, New York, N. Y., February, 1934.

[1]Enthalpy is defined by the equation $h = u + Apv$ in which u denotes intrinsic energy. Applying the energy equation of thermodynamics to a change of state *at constant pressure*, it turns out that the change of enthalpy gives exactly the quantity of heat absorbed. Enthalpy is sometimes called *heat content;* but this latter expression deserves the earliest possible abandonment for the fundamental reason that heat is an external performance, not a property, and as such, cannot be contained.

Table 1

Temperature (F)	Quality ($P_o = 30$"Hg): Weight of Saturated Vapor per Pound Dry Air	Quality ($P_o = 30$"Hg): Correction Factor for Total Pressure *	Specific Enthalpy of Liquid (or Solid) Water (Btu/lb)	Enthalpy (Btu/lb Dry Air) ($P_o = 30$"Hg): Dry Air ($\mu = 0$)		Enthalpy (Btu/lb Dry Air) ($P_o = 30$"Hg): Just-saturated Mixture ($\mu = 1$)	Volume (Ft^3/lb Dry Air) ($P_o = 30$"Hg): Dry Air ($\mu = 0$)		Volume (Ft^3/lb Dry Air) ($P_o = 30$"Hg): Just-Saturated Mixture ($\mu = 1$)	Wet-Bulb Depression (F) ($P_o = 30$"Hg): Dry Air ($\mu = 0$)		Wet-Bulb Depression (F) ($P_o = 30$"Hg): Constant **
t	z''_o	a	h'_w	h'_o	h''_o-h'_o	h''_o	v'_o	v''_o-v'_o	v''_o	δ'	μ_c†	b
0	0.000783	0.0334	−158.8	20.39	0.83	21.22	11.56	0.01	11.57	3.35	.....	0.016
2	0.000870	0.0334	−157.9	20.87	0.92	21.79	11.61	0.01	11.62	3.65	.....	0.019
4	0.000965	0.0334	−157.0	21.35	1.03	22.38	11.66	0.02	11.68	3.98	.....	0.022
6	0.001069	0.0334	−156.0	21.83	1.14	22.97	11.71	0.02	11.73	4.39	.....	0.026
8	0.001183	0.0334	−155.1	22.31	1.26	23.57	11.76	0.02	11.78	4.72	.....	0.030
10	0.001308	0.0334	−154.1	22.79	1.40	24.19	11.81	0.02	11.83	5.12	.....	0.033
12	0.001446	0.0334	−153.2	23.27	1.55	24.82	11.86	0.03	11.89	5.55	.....	0.036
14	0.001597	0.0334	−152.2	23.75	1.71	25.46	11.91	0.03	11.94	6.00	.....	0.040
16	0.001762	0.0334	−151.3	24.23	1.88	26.11	11.96	0.03	11.99	6.48	.....	0.044
18	0.001943	0.0334	−150.3	24.71	2.08	26.79	12.01	0.04	12.05	6.99	.....	0.049
20	0.002140	0.0335	−149.3	25.19	2.29	27.48	12.06	0.04	12.10	7.52	.....	0.054
22	0.002356	0.0335	−148.4	25.67	2.52	28.19	12.11	0.05	12.16	8.08	.....	0.061
24	0.002591	0.0335	−147.4	26.15	2.78	28.93	12.16	0.05	12.21	8.66	.....	0.069
26	0.002848	0.0335	−146.4	26.63	3.06	29.69	12.21	0.06	12.27	9.27	.....	0.078
28	0.003128	0.0335	−145.4	27.11	3.36	30.47	12.26	0.06	12.32	9.91	.....	0.087
30	0.003432	0.0335	−144.5	27.59	3.69	31.28	12.31	0.07	12.38	10.57	.....	0.098
32	0.003763	0.0335	−143.5	28.07	4.05	32.12	12.36	0.08	12.44	11.26	.....	0.109
33	0.003920	0.0335	1.0	28.31	4.22	32.53	12.39	0.07	12.46	(11.03)†	0.910	0.079
34	0.004082	0.0335	2.0	28.55	4.39	32.94	12.41	0.08	12.49	(11.36)	0.826	0.084
35	0.004251	0.0336	3.0	28.79	4.57	33.36	12.44	0.08	12.52	(11.70)	0.746	0.089
36	0.004425	0.0336	4.0	29.03	4.76	33.79	12.46	0.09	12.55	(12.04)	0.672	0.094
37	0.004606	0.0336	5.0	29.27	4.96	34.23	12.49	0.09	12.58	(12.39)	0.603	0.099
38	0.004792	0.0336	6.0	29.51	5.16	34.67	12.51	0.10	12.61	(12.74)	0.539	0.104
39	0.004985	0.0336	7.0	29.75	5.37	35.12	12.54	0.10	12.64	(13.10)	0.478	0.109
40	0.005183	0.0336	8.1	29.99	5.59	35.58	12.56	0.11	12.67	(13.46)	0.421	0.115
41	0.005390	0.0336	9.1	30.23	5.81	36.04	12.59	0.11	12.70	(13.83)	0.369	0.120
42	0.005604	0.0336	10.1	30.47	6.05	36.52	12.61	0.12	12.73	(14.20)	0.320	0.126
43	0.005826	0.0336	11.1	30.71	6.29	37.00	12.64	0.12	12.76	(14.58)	0.274	0.131
44	0.006056	0.0336	12.1	30.95	6.54	37.49	12.66	0.13	12.79	(14.96)	0.231	0.137
45	0.006294	0.0337	13.1	31.19	6.80	37.99	12.69	0.13	12.82	(15.34)	0.191	0.142
46	0.006540	0.0337	14.1	31.43	7.07	38.50	12.71	0.14	12.85	(15.73)	0.154	0.148
47	0.006794	0.0337	15.1	31.67	7.35	39.02	12.74	0.14	12.88	(16.12)	0.119	0.153
48	0.007058	0.0337	16.1	31.91	7.63	39.54	12.76	0.15	12.91	(16.51)	0.087	0.159
49	0.007330	0.0337	17.1	32.15	7.93	40.08	12.79	0.15	12.94	(16.90)	0.057	0.164
50	0.007612	0.0337	18.1	32.39	8.24	40.63	12.81	0.16	12.97	(17.32)	0.029	0.172
51	0.007903	0.0337	19.1	32.63	8.56	41.19	12.84	0.16	13.00	(17.74)	0.003	0.178
52	0.008204	0.0337	20.1	32.87	8.89	41.76	12.86	0.17	13.03	18.16	.....	0.185
53	0.008517	0.0337	21.1	33.11	9.23	42.34	12.89	0.18	13.07	18.58	.....	0.191
54	0.008841	0.0337	22.1	33.35	9.59	42.94	12.91	0.19	13.10	19.01	.....	0.198
55	0.009175	0.0338	23.1	33.59	9.95	43.54	12.94	0.19	13.13	19.44	.....	0.205
56	0.009519	0.0338	24.1	33.83	10.33	44.16	12.96	0.20	13.16	19.88	.....	0.212
57	0.009875	0.0339	25.1	34.07	10.72	44.79	12.99	0.20	13.19	20.32	.....	0.219
58	0.01024	0.0339	26.1	34.31	11.12	45.43	13.01	0.22	13.23	20.77	.....	0.226
59	0.01062	0.0339	27.1	34.55	11.54	46.09	13.04	0.22	13.26	21.22	.....	0.233
60	0.01102	0.0339	28.1	34.79	11.97	46.76	13.06	0.24	13.30	21.67	.....	0.241
61	0.01142	0.0340	29.1	35.03	12.42	47.45	13.09	0.24	13.33	22.13	.....	0.248
62	0.01184	0.0340	30.1	35.27	12.88	48.15	13.11	0.25	13.36	22.60	.....	0.256
63	0.01227	0.0340	31.1	35.51	13.35	48.86	13.14	0.26	13.40	23.07	.....	0.264
64	0.01272	0.0340	32.1	35.75	13.84	49.59	13.17	0.26	13.43	23.54	.....	0.272
65	0.01318	0.0340	33.1	35.99	14.35	50.34	13.19	0.28	13.47	24.02	.....	0.280
66	0.01366	0.0341	34.1	36.23	14.88	51.11	13.22	0.29	13.51	24.51	.....	0.289
67	0.01415	0.0341	35.1	36.47	15.42	51.89	13.24	0.30	13.54	24.99	.....	0.298
68	0.01466	0.0341	36.1	36.71	15.98	52.69	13.27	0.31	13.58	25.49	.....	0.307
69	0.01519	0.0342	37.1	36.94	16.57	53.51	13.29	0.33	13.62	25.98	.....	0.316
70	0.01573	0.0342	38.1	37.18	17.17	54.35	13.32	0.33	13.65	26.48	.....	0.326
71	0.01629	0.0342	39.1	37.42	17.79	55.21	13.34	0.35	13.69	26.99	.....	0.335
72	0.01687	0.0342	40.1	37.66	18.42	56.08	13.37	0.36	13.73	27.50	.....	0.345
73	0.01746	0.0343	41.1	37.90	19.08	56.98	13.39	0.38	13.77	28.01	.....	0.355
74	0.01808	0.0343	42.1	38.14	19.76	57.90	13.42	0.39	13.81	28.53	.....	0.365

Table 1—Continued

Temperature (F)	Quality ($P_o = 30$"Hg): Weight of Saturated Vapor per Pound Dry Air	Quality ($P_o = 30$"Hg): Correction Factor for Total Pressure *	Specific Enthalpy of Liquid (or Solid) Water (Btu/lb)	Enthalpy (Btu/lb Dry Air) ($P_o = 30$"Hg): Dry Air ($\mu = 0$)		Enthalpy (Btu/lb Dry Air) ($P_o = 30$"Hg): Just-saturated Mixture ($\mu = 1$)	Volume (Ft^3/lb Dry Air) ($P_o = 30$"Hg): Dry Air ($\mu = 0$)		Volume (Ft^3/lb Dry Air) ($P_o = 30$"Hg): Just-Saturated Mixture ($\mu = 1$)	Wet-Bulb Depression (F) ($P_o = 30$"Hg): Dry Air ($\mu = 0$)		Wet-Bulb Depression (F) ($P_o = 30$"Hg): Constant **
t	z''_o	a	h'_w	h'_o	$h''_o - h'_o$	h''_o	v'_o	$v''_o - v'_o$	v''_o	δ'	μ_c†	b
75	0.01871	0.0343	43.1	38.38	20.45	58.83	13.44	0.41	13.85	29.05	.....	0.375
76	0.01936	0.0344	44.1	38.62	21.18	59.80	13.47	0.42	13.89	29.57	.....	0.385
77	0.02004	0.0344	45.1	38.86	21.92	60.78	13.49	0.44	13.93	30.10	.....	0.395
78	0.02073	0.0345	46.1	39.10	22.69	61.79	13.52	0.45	13.97	30.63	.....	0.406
79	0.02145	0.0345	47.1	39.34	23.49	62.83	13.54	0.47	14.01	31.17	.....	0.417
80	0.02219	0.0345	48.1	39.58	24.31	63.89	13.57	0.48	14.05	31.71	.....	0.428
81	0.02295	0.0346	49.1	39.82	25.15	64.97	13.59	0.50	14.09	32.26	.....	0.438
82	0.02373	0.0346	50.1	40.06	26.02	66.08	13.62	0.52	14.14	32.81	.....	0.449
83	0.02454	0.0347	51.1	40.30	26.92	67.22	13.64	0.54	14.18	33.36	.....	0.460
84	0.02538	0.0347	52.0	40.54	27.84	68.38	13.67	0.56	14.23	33.91	.....	0.471
85	0.02624	0.0347	53.0	40.78	28.80	69.58	13.69	0.58	14.27	34.47	.....	0.483
86	0.02713	0.0348	54.0	41.02	29.79	70.81	13.72	0.60	14.32	35.04	.....	0.495
87	0.02805	0.0348	55.0	41.26	30.81	72.07	13.74	0.62	14.36	35.60	.....	0.508
88	0.02899	0.0349	56.0	41.50	31.87	73.37	13.77	0.64	14.41	36.17	.....	0.521
89	0.02997	0.0349	57.0	41.74	32.96	74.70	13.79	0.67	14.46	36.75	.....	0.534
90	0.03097	0.0350	58.0	41.98	34.08	76.06	13.82	0.69	14.51	37.33	.....	0.548
91	0.03201	0.0351	59.0	42.22	35.24	77.46	13.84	0.72	14.56	37.91	.....	0.562
92	0.03308	0.0351	60.0	42.46	36.44	78.90	13.87	0.74	14.61	38.50	.....	0.576
93	0.03419	0.0352	61.0	42.70	37.67	80.37	13.89	0.77	14.66	39.09	.....	0.590
94	0.03533	0.0352	62.0	42.94	38.94	81.88	13.92	0.79	14.71	39.68	.....	0.604
95	0.05651	0.0353	63.0	43.18	40.25	83.43	13.94	0.82	14.76	40.27	.....	0.618
96	0.03772	0.0354	64.0	43.42	41.60	85.02	13.97	0.85	14.82	40.86	.....	0.632
97	0.03897	0.0354	65.0	43.66	42.99	86.65	14.00	0.87	14.87	41.46	.....	0.646
98	0.04025	0.0355	66.0	43.90	44.42	88.32	14.02	0.91	14.93	42.06	.....	0.661
99	0.04157	0.0356	67.0	44.14	45.90	90.04	14.05	0.93	14.98	42.66	.....	0.675
100	0.04293	0.0356	68.0	44.38	47.41	91.79	14.07	0.97	15.04	43.27	.....	0.690
101	0.04434	0.0357	69.0	44.62	48.97	93.59	14.10	1.00	15.10	43.88	.....	0.705
102	0.04578	0.0358	70.0	44.86	50.59	95.45	14.12	1.04	15.16	44.49	.....	0.720
103	0.04727	0.0359	71.0	45.10	52.26	97.36	14.15	1.07	15.22	45.11	.....	0.735
104	0.04881	0.0359	72.0	45.34	53.98	99.32	14.17	1.11	15.28	45.73	.....	0.750
105	0.05040	0.0360	73.0	45.58	55.76	101.34	14.20	1.15	15.35	46.35	.....	0.765
106	0.05204	0.0361	74.0	45.81	57.60	103.41	14.22	1.19	15.41	46.98	.....	0.781
107	0.05373	0.0362	75.0	46.05	59.49	105.54	14.25	1.23	15.48	47.61	.....	0.797
108	0.05547	0.0363	76.0	46.29	61.44	107.73	14.27	1.27	15.54	48.24	.....	0.813
109	0.05726	0.0364	77.0	46.53	63.45	109.98	14.30	1.31	15.61	48.88	.....	0.830
110	0.05910	0.0365	78.0	46.77	65.53	112.30	14.32	1.36	15.68	49.51	.....	0.847
111	0.06100	0.0366	79.0	47.01	67.67	114.68	14.35	1.40	15.75	50.15	.....	0.864
112	0.06296	0.0367	80.0	47.25	69.87	117.12	14.37	1.45	15.82	50.80	.....	0.882
113	0.06498	0.0368	81.0	47.49	72.15	119.64	14.40	1.50	15.90	51.44	.....	0.900
114	0.06707	0.0369	82.0	47.73	74.49	122.22	14.42	1.55	15.97	52.09	.....	0.918
115	0.06922	0.0370	83.0	47.97	76.92	124.89	14.45	1.60	16.05	52.73	.....	0.937
116	0.07143	0.0372	84.0	48.21	79.42	127.63	14.47	1.66	16.13	53.39	.....	0.956
117	0.07372	0.0373	85.0	48.45	82.00	130.45	14.50	1.71	16.21	54.04	.....	0.975
118	0.07609	0.0374	86.0	48.69	84.66	133.35	14.52	1.77	16.29	54.70	.....	0.995
119	0.07854	0.0375	86.9	48.93	87.40	136.33	14.55	1.83	16.38	55.36	.....	1.015
120	0.08106	0.0377	87.9	49.17	90.22	139.39	14.57	1.90	16.47	56.02	.....	1.03
121	0.08365	0.0378	88.9	49.41	93.13	142.54	14.60	1.95	16.55	56.68	.....	1.05
122	0.08630	0.0380	89.9	49.65	96.14	145.79	14.62	2.03	16.65	57.34	.....	1.07
123	0.08903	0.0381	90.9	49.89	99.25	149.14	14.65	2.09	16.74	58.02	.....	1.09
124	0.09185	0.0382	91.9	50.13	102.42	152.55	14.67	2.16	16.83	58.69	.....	1.11
125	0.09478	0.0384	92.9	50.37	105.73	156.10	14.70	2.23	16.93	.....	.....	.....
126	0.09779	0.0386	93.9	50.61	109.15	159.76	14.72	2.31	17.03	.....	.....	.....
127	0.1009	0.0387	94.9	50.85	112.67	163.52	14.75	2.38	17.13	.....	.....	.....
128	0.1042	0.0389	95.9	51.09	116.29	167.38	14.77	2.47	17.24	.....	.....	.....
129	0.1075	0.0391	96.9	51.33	120.03	171.36	14.80	2.55	17.35	.....	.....	.....

*For use in the formula, $z'' = \dfrac{z''_o}{1 + a\,(P - P_o)}$

**For use in the empirical equation, $\delta = \dfrac{1 - \mu}{1 + b\mu}\delta'$ or $\mu = \dfrac{\delta'/\delta - 1}{\delta'/\delta + b}$

†The figure in parentheses is not the true wet-bulb depression of dry air. It can be used in the empirical equation, however, provided the percentage humidity is greater than the critical value μ_c.

accurate work, the constant B_w requires some adjustment in order to reproduce the experimental data at the higher temperatures. For ordinary calculations, the theoretical value $B_w = 1544/18.016 = 85.70$ (ft/F) may be used throughout.

(3) *Specific Enthalpy.* Values for the specific enthalpy of saturated water vapor are to be found in the 1932 Knoblauch Tables (*Tabellen und Diagramme für Wasserdampf*). These tables are recommended because there is reason to think that they can be extrapolated to temperatures below 32 F with somewhat more certainty than others. This extrapolation is made by means of the equation,

$$h''_w = 1074.4 + 0.440\ (t - 32)\ \text{(Btu/lb)} \quad \ldots\ldots (4)$$

which appears to give correct results for temperatures below about 86 F.

Superheated Vapor

Direct experimental data on the thermodynamic properties of superheated water vapor are lacking for the range of temperature and pressure encountered in heating and ventilating. However, the assumption that the constant B_w and the specific enthalpy h_w are functions of the temperature[2] only can be relied upon to give sufficiently accurate results. This assumption implies, for example, that Eq. (4) also gives the specific enthalpy of the superheated water vapor (for temperatures below 86 F).

Liquid (or Solid)

Within the limits of accuracy desired, there is seldom any need of considering the specific volume of the liquid (or solid). The specific enthalpy, however, is an important item. It is denoted by h'_w and is listed in Column 4, Table 1.

Mixtures of Dry Air and Water: Classification

Using the word *water* to refer to the substance H_2O without regard to the particular phase or phases in which it may appear, we denote by z the ratio *by weight* of water to dry air in a given mixture and call z the *quality*[3] of this mixture. It is convenient to study mixtures of dry air and water, in general, under the following classification:

(1) *Saturated Mixtures* in which the water appears in at least two phases; namely, saturated vapor and saturated liquid if the temperature of the mixture is above 32 F; or saturated vapor and saturated solid (ice) if the temperature of the mixture is below 32 F. Let z' denote the ratio *by weight* of liquid (or solid) to dry air and z'', the weight of saturated vapor per pound of dry air; then $z' + z'' = z$.

(2) *Just-saturated Mixtures* in which the amount of liquid (or solid) is too small to contribute to the thermal properties of the mixture otherwise than by merely insuring that the vapor is actually saturated. The quality of a just-saturated mixture is z''.

(3) *Unsaturated Mixtures* in which the water appears in only one phase, namely, superheated vapor. The quality of such a mixture is z. Let z'' be the quality of the corresponding just-saturated mixture having the same temperature t (and same total pressure P) and let z be compared with z''. The ratio z/z'' is called the *percentage humidity* of the given unsaturated mixture and is denoted by the letter μ.

[2]Strictly speaking, this assumption violates the laws of thermodynamics; for, if B_w varies with the temperature, h_w must vary with the volume. At higher temperatures, the error involved in this assumption may become significant (1 per cent or more), but at lower temperatures it is negligible.

[3]The term "humidity" is widely used to denote the ratio by weight of water vapor to dry air. What is desired here is a term to denote the ratio by weight of water to dry air even when a considerable portion of the water is in the liquid or solid state.

Dalton's Law

According to Dalton's Law, the partial pressure of any constituent of a mixture of *gases* is exactly equal to the pressure that that constituent would exert if alone in the whole volume of the mixture and at the same temperature. It has been pointed out (Jakob, *Zeitschrift für Physik,* 41 [1927] 737) that Dalton's Law only applies strictly to mixtures of perfect gases; but, its application to atmospheric air will not involve significant error.

Just-Saturated Mixtures

Consider, first of all, any just-saturated mixture, temperature t, total pressure P. The percentage humidity of such a mixture is unity, by definition. The partial pressures, p_a (dry air) and p''_w (saturated water vapor) satisfy the equation,

$$p_a + p''_w = P \quad \ldots\ldots (5)$$

Moreover, it is always assumed that both dry air and saturated water vapor occupy *independently* the whole volume of the mixture; hence,

$$v_a = z''\, v''_w = v'' \quad \ldots\ldots (6)$$

in which v'' denotes the volume of the given just-saturated mixture (per pound of dry air) and z'', its quality.

(1) *Quality.* To apply Dalton's Law, calculate v_a and v''_w from Eq. (1) and (3), respectively, and, by making use of (5), write Eq. (6) as follows,

$$\frac{B_a T}{(P - p''_w)} = z'' \frac{B_w T}{p''_w}$$

whence,

$$z'' = \frac{B_a}{B_w} \frac{p''_w}{(P - p''_w)} \quad \ldots\ldots (7)$$

Equation (7) affords the means of determining the quality of a given just-saturated mixture. Column 2, Table 1, gives values of z'' for a total pressure $P_o = 30$ in. Hg. as calculated from (7) using values of p''_w corrected for the presence of dry air as explained before.

(2) *Volume.* Dalton's Law may be applied in a slightly different way to calculate the volume v'' (per pound of dry air) of a just-saturated mixture. Thus, p_a and p''_w are calculated from Eq. (1) and (3) and introduced into (5) as follows,

$$\frac{B_a \times T}{v_a} + \frac{B_w \times T}{v''_w} = P$$

Then, making use of (6),

$$v'' = \frac{B_a \times T}{P} + z'' \frac{B_w \times T}{P} \quad \ldots\ldots (8)$$

Equation (8) shows that v'' is made up of two parts; the first is the contribution of the dry air itself to the total volume of the mixture and may be denoted by v' (when it is desired to refer to the specific volume of the liquid—or solid—the subscript "W" is affixed; thus, v'_w); the second is the contribution of the saturated vapor. Columns 8, 9, and 10, Table 1, give values of v', $(v'' - v')$ and v'', respectively, all for a total pressure $P_o = 30$ in. Hg.

(3) *Enthalpy.* The enthalpy of a mixture of perfect gases is exactly the sum of the enthalpies of its constituents. This statement, like Dalton's Law, is only approximately correct for mixtures of actual gases and vapors. Still, its application to atmospheric air involves no significant error so,

$$h'' = h_a + z''\, h''_w \quad \ldots\ldots (9)$$

for a just-saturated mixture. Here again, the contribution of the dry air itself is denoted by h'; that is, $h' = h_a$. Columns 5, 6, and 7, Table 1, give values of h', $(h'' - h')$ and h'', respectively, all for a total pressure, $P_o = 30$ in. Hg.

Saturated Mixtures

In a saturated mixture, the liquid (or solid) occupies exclusively a portion of the total volume. This portion is usually so small, however, that it may be neglected. The contribution of the liquid (or solid) to the total enthalpy of the mixture cannot be neglected, however. Let z' denote the weight of this liquid (or solid) per pound of dry air; then, its contribution to the enthalpy of the mixture per pound of dry air is $z'h'_w$ and we have,

$$h = h'' + z'h'_w \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

As an example showing the use that can be made of Table 1 in this connection, let it be required to find the volume and enthalpy of a saturated mixture, temperature 70 F, total pressure 30 in. Hg., quality 0.02. From Table 1, $z'' = 0.01573$ whence $z' = 0.00427$; therefore, the enthalpy is

$$h = 54.35 + 0.00427 \times 38.1 = 54.51 \text{ Btu/lb dry air.}$$

The volume of the mixture is obtained directly from the table, if no allowance for the volume occupied by the liquid itself is made. Thus

$$v = 13.65 \text{ ft}^3\text{/lb dry air.}$$

Unsaturated Mixtures

Remembering that the quality of an unsaturated mixture may be expressed in terms of its percentage humidity by the simple equation, $z = \mu z''$, in which z'' refers to the quality of the corresponding just-saturated mixture having the *same* temperature t and same total pressure P, simple expressions for volume and enthalpy in terms of percentage humidity can be indicated as follows:

(1) *Volume.* The volume (per pound of dry air) is

$$v = v' + \mu\,(v'' - v') \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

(2) *Enthalpy.* The enthalpy (per pound of dry air) is

$$h = h' + \mu\,(h'' - h') \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

The arrangement of Table 1 is designed to make full use of the simple linear relations expressed by Eq. (11) and (12). For example, let it be required to find the volume and enthalpy of an unsaturated mixture, temperature 70 F, percentag humidity 40 per cent, total pressure 30 in. Hg. Then

$$v = 13.32 + 0.4 \times 0.33 = 13.35 \text{ ft}^3\text{/lb dry air.}$$
$$h = 37.18 + 0.4 \times 17.17 = 44.05 \text{ Btu/lb dry air.}$$

(3) *Dew-point.* Any unsaturated mixture possesses two additional properties of practical importance; namely, dew-point and wet-bulb temperatures. Let the given mixture be cooled at constant total pressure P and constant quality z until its contained moisture just starts to condense. The temperature reached is called the *dewpoint* of the given unsaturated mixture. Dew-points are easily obtained by interpolation from Table 1. Thus, for a mixture, temperature 70 F, percentage humidity 40 per cent, total pressure 30 in. Hg., the quality is

$$z = 0.4 \times 0.01573 = 0.006292.$$

But, 0.006292 is the quality of a just-saturated mixture at 45.0 F. Hence, 45.0 F is the dew-point, t_d, of the given mixture.

(4) *Wet-bulb.* In a later paragraph, a thermodynamic definition of wet-bulb temperature will be given. For the present, however, the use that can be made of Table 1 in computing wet-bulb temperatures on the basis of an empirical equation whose constants have been adjusted to give accurate results, will be indicated. Thus, Column 11 gives the *wet-bulb depression* δ' of dry air and Column 12 gives the value of the constant b both appearing in the empirical equation,

$$\delta = \frac{1-\mu}{1+b\mu}\delta' \quad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

in which δ is the wet-bulb depression of the given mixture, percentage humidity μ, total pressure 30 in. Hg.

For atmosphere air, temperature 70 F, percentage humidity 40 per cent, total pressure 30 in. Hg, the wet-bulb depression is

$$\delta = \frac{0.6 \times 26.48}{1.1304} = 14.05$$

Hence, the wet-bulb temperature itself is

$$t_w = 55.95 \text{ F.}$$

Between 32 F and 51.13 F, Eq.(13) can only be used for values of percentage humidity greater than a certain critical value μ_c at which ice would form in the wet-bulb thermometer. Even when this restriction is observed, it is necessary to use a fictitious value for δ' in Eq. (13), the fact that this value is not the true wet-bulb depression of dry air being indicated by parentheses in Table 1. For example, the wet-bulb temperature of a mixture, temperature 40 F, percentage humidity 60 per cent, is

$$t_w = 40 - \frac{0.4 \times 13.46}{1.069} = 34.97 \text{ F.}$$

The wet-bulb of a mixture at the same temperature but percentage humidity less than the critical value, 0.421, cannot be calculated from Table 1 directly.

Corrections for Total Pressure

All items in Table 1 are computed for a total pressure, $P_o = 30$ in. Hg. Frequently, however, it is desired to obtain values for a different total pressure, say $P = P_o + \Delta P$. This is easily accomplished through the use of the constant a, Column 3. Thus, for a mixture, percentage humidity μ, total pressure P;

$$\text{(a)} \quad z = \frac{\mu z_o''}{1 + a\,(P - P_o)}$$

$$\text{(b)} \quad h = h_o' + \frac{\mu(h_o'' - h_o')}{1 + a\,(P - P_o)}$$

$$\text{(c)} \quad v = \frac{P_o}{P}\left[v_o' + \frac{\mu(v_o'' - v_o')}{1 + a\,(P - P_o)}\right]$$

The corresponding total-pressure correction for the dew-point and wet-bulb have not yet been worked out. In this respect, Table 1, is still somewhat incomplete.

As an example, let it be required to find the quality, enthalpy, and volume of a mixture, temperature 70 F, percentage humidity 40 per cent, total pressure 25 in. Hg. They are:

$$\text{(a)} \quad z = \frac{0.4 \times 0.01573}{0.829} = 0.007589 \text{ lb/lb dry air}$$

$$\text{(b)} \quad h = 37.18 + \frac{0.4 \times 17.17}{0.829} = 45.47 \text{ Btu/lb dry air}$$

$$\text{(c)} \quad v = \frac{30}{25}\left[13.32 + \frac{0.4 \times 0.33}{0.829}\right] = 16.18 \text{ ft}^3\text{/lb dry air}$$

Mixing Processes

Having investigated and defined the various thermodynamic properties of mixtures of dry air and water of

practical importance, an analysis of the various processes involved in problems of heating and ventilating can be made. Consider a continuous-flow mixing process in which $m_1(1+z_1)$ lb per minute of Mixture 1, $m_2(1+z_2)$ lb per minute of Mixture 2, and m_w lb per minute of pure water (solid, liquor or vapor) unite to form $(1+z)$ lb per minute of Resulting Mixture. Weight balances for the dry air and water separately require,

$$m_1 + m_2 = 1 \quad \text{(14a)}$$
$$m_1 z_1 + m_2 z_2 + m_w = z \quad \text{(14b)}$$

If all velocities are low so that no allowance for kinetic energies need be made, then the total enthalpy of the Resulting Mixture will equal the sum of the enthalpies of the component mixtures plus any heat absorbed from outside. Let the amount of heat thus absorbed from outside *per pound of dry air in the Resulting Mixture* be q Btu; then,

$$m_1 h_1 + m_2 h_2 + m_w h_w = h - q \quad \text{(14c)}$$

in which h_1, h_2 and h are enthalpies per pound of dry air and h_w is the specific enthalpy of the water. Equations (14) may be said to describe the mixing process under consideration.

For some applications, Eq. (14) are used directly; for others, it is convenient to solve them for m_1, m_2 and m_w. This solution, for the special case of adiabatic mixing, $q = 0$, is

$$m_1 = \frac{(h - h_2) - h_w(z - z_2)}{(h_1 - h_2) - h_w(z_1 - z_2)} \quad \text{(15a)}$$
$$m_2 = 1 - m_1 \quad \text{(15b)}$$
$$m_w = (z - z_2) - m_1(z_1 - z_2) \quad \text{(15c)}$$

Finally, two special applications of Eq. (15) are frequently used, namely:

Case I: $m_w = 0$

$$m_1 = \frac{h - h_2}{h_1 - h_2} = \frac{z - z_2}{z_1 - z_2} \quad \text{(16)}$$
$$m_2 = 1 - m_1$$

Case II: $m_2 = 0$

$$m_w = \frac{h - h_1}{h_w} = z - z_1 \quad \text{(17)}$$
$$m_1 = 1$$

The use of these equations may be illustrated by the following examples: (1) Outside Air, temperature 0 F, percentage humidity 25 per cent, is mixed adiabatically with recirculated Inside Air, temperature 70 F, percentage humidity 40 per cent. What volume of Inside Air will be required per cubic foot of Outside Air in order that the resulting temperature will be just 30 F?

Find the resulting percentage humidity. The total pressure may be assumed to be 30 in Hg.

From Table 1, the following data are obtained:

	Outside Air	*Inside Air*	*Resulting Mixture*
Quality:	$z_1 = 0.000196$	$z_2 = 0.006292$	$z = 0.003432\mu$
Volume	$v_1 = 11.56$	$v_2 = 13.45$	
Enthalpy:	$h_1 = 20.60$	$h_2 = 44.05$	$h = 27.59 + 3.69\mu$

Since the mixing is adiabatic and, in addition, $m_w = 0$, Eq. (16) may be used directly; thus

$$m_1 = \frac{16.46 - 3.69\mu}{23.45} = \frac{0.006292 - 0.003432\mu}{0.006096}$$

from which

$$\mu = 0.814 \qquad m_1 = 0.574 \qquad m_2 = 0.426$$

Finally, the volume of Inside Air per cubic foot of Outside Air is

$$\frac{0.426 \times 13.45}{0.574 \times 11.56} = 0.864 \text{ cu ft}$$

(2) Referring to Example 1, suppose Inside Air and Outside Air to be mixed adiabatically in the proportion of 1 cu ft of the former to 2 cu ft of the latter. Find the temperature and percentage humidity of the Resulting Mixture.

In the first place,

$$13.45\, m_2 = 5.78\, m_1$$
$$m_2 = 1 - m_1$$

so that

$$m_1 = 0.700$$
$$m_2 = 0.300$$

Eq. (14) may now be used directly (with $q = 0$) to determine z and h for the Resulting Mixture. They are

$$z = 0.700 \times 0.000196 + 0.300 \times 0.006292 = 0.002025$$
$$h = 0.700 \times 20.60 + 0.300 \times 44.05 = 27.63$$

At $t = 21.2$ F (found by trial and error)

$$h = 25.48 + \frac{0.002025}{0.002270} \times 2.43 = 27.64 \text{ (should be 27.63)}$$

Hence,

$$t = 21.2 \text{ F and } \mu = \frac{0.002025}{0.002270} = 0.892$$

Wet-Bulb Temperature: Thermodynamic Definition

Every unsaturated mixture exhibits an important thermodynamic property called *wet-bulb temperature*. Suppose that the given mixture is made to move continuously over the surface of a thin film of liquid (or solid) water. This motion will cause continuous evaporation from the surface and the water thus evaporated will diffuse through a bounding layer of air, in which are established more or less steep temperature and quality gradients, to the given mixture. Moreover, these temperature and quality gradients in the bounding layer will reduce the given mixture to a just-saturated mixture right at the liquid (or solid) surface. The temperature of this just-saturated mixture may at first be quite different from that of the liquid (or solid) itself; but, if the film of liquid (or solid) is thin enough not to resist the necessary temperature change, this difference will gradually disappear and a steady state will ultimately be reached in which the temperature of the liquid (or solid) and that of the adjacent just-saturated mixture are sensibly equal. This steady temperature assumed by the liquid (or solid) is the wet-bulb temperature of the given unsaturated mixture. It may be denoted by t_w.

To reach a thermodynamic definition of wet-bulb temperature, it is customary to assume that the whole process of evaporation and subsequent mixing is adiabatic. This amounts to assuming that the effects of radiation can be excluded. To the evaporation itself, Eq. (17) applies as follows:

$$\frac{(h'')^* - h}{(z'')^* - z} = (h'_w)^*$$

in which the asterisk indicates that the designated quantities are to be evaluated at the wet-bulb temperature.

To the subsequent mixing, Eq. (16) applies as follows:

$$\frac{(h'')^* - h}{(z'')^* - z} = \frac{(h'')^* - h_1}{(z'')^* - z_1}$$

in which (h_1, z_1) is the state of the air whose wet-bulb is being measured. Combining,

$$\frac{(h'')^* - h_1}{[(z'')^* - z_1]\,(h'_w)^*} = 1 \qquad (18)$$

Equation (18) is the thermodynamic definition of the wet-bulb temperature used in evaluating the constants δ' and b appearing in Table 1. The derivation given here is that of Mollier (*Das ix-Diagramm für Dampfluftgemische:* Stodola Festschrift, 1929). It is based upon the so-called convection theory which has just recently received critical examination by Arnold (*Physics:* 4, 1933, 255) who contends that it fails to give correct results for liquids other than water.

Applications to Air Conditioning

(1) *Heating and Humidifying—No Recirculation.* Air is to be supplied to a building at 70 F, percentage humidity 40 per cent. The outside temperature is 0 F, percentage humidity 25 per cent.

The dew-point of the Inside Air is 45.0 F. Consequently, if the Outside Air can be reduced to a just-saturated mixture at 45.0 F, subsequent addition of heat will bring it to 70 F and 40 per cent percentage humidity as required. In actual practice, this is accomplished by: (1) increasing the wet-bulb temperature of Outside Air to 45 F by the addition of heat from so-called tempering coils; (2) introducing water from a spray at 45 F to reduce the Outside Air to a just-saturated mixture at 45 F—this is called *adiabatic saturation;* (3) adding heat from reheater coils to produce Inside Air. The following data may be assembled from Table 1:

	Outside Air	After Tempering Coils	After Sprays	Inside Air
Temperature F.	0	(72.1)	45.0	70
Percentage Humidity.	25%	.....	100%	40%
Quality	0.000196	0.000196	0.006292	0.006292
Enthalpy	20.60	(37.91)	37.99	44.05
Volume	11.56	.....	.....	13.45

Equations (17) apply to processes (1) plus (2) provided, of course, that h be replaced by $(h - q)$; thus,

$$m_w = \frac{(37.99 - q) - 20.60}{13.1} = 0.006292 - 0.000196$$

from which, $m_w = 0.006096$ and $q = 17.31$ Btu/lb dry air. The enthalpy of the mixture leaving the tempering coils is evidently 37.91 Btu/lb dry air $(= 20.60 + 17.31)$ and its quality is 0.000196; hence, its temperature is easily found to be 72.1 F.

The tempering coils must add 17.31 Btu of heat, the spray, 0.006096 lb of water at 45, and the reheater, 6.06 Btu of heat—all per pound of dry air. If 15,000 cu ft per minute of Inside Air is required, only $15{,}000 \times \frac{11.56}{13.45} = 12{,}900$ cu ft per minute of Outside Air need be handled.

(2) *Heating and Humidifying—With Recirculation.* Use the data of the preceding example, but allow sufficient recirculation to make the use of the tempering coils unnecessary. Equations (15) apply directly as follows:

$$m_1 = \frac{(37.99 - 20.60) - 13.1\,(0.006292 - 0.000196)}{(44.05 - 20.60) - 13.1\,(0.006292 - 0.000196)} = 0.741$$

$$m_2 = 0.259$$

$$m_w = 0.006096 - 0.741 \times 0.006096 = 0.00158$$

Therefore, if 15,000 cfm of Inside Air is required, $15{,}000 \times 0.741 = 11{,}100$ cfm must be recirculated with $15{,}000 \times 0.259 \times \frac{11.56}{13.45} = 3{,}340$ cfm of Outside Air.

The heat required from the heater is the same as before; the amount of 45 deg water to be furnished from the spray is 0.00158 lb/lb dry air.

(3) *Cooling and Dehumidifying—No Recirculation.* Air is to be supplied to a building at 80 deg, percentage humidity 35 per cent. The outside temperature is 90 deg, percentage humidity 49 per cent.

The usual scheme for accomplishing the desired change is: (1) cool the Outside Air to the dew-point of the Inside Air by external refrigeration in the form of a cold water spray; (2) remove the liquid thus formed by passing over eliminator plates; (3) reheat the resulting just-saturated mixture to the desired Inside Air conditions. The following data can be obtained from Table 1:

	Outside Air	After Spray	After Eliminator	Inside Air
Temperature F.	90	50.5	50.5	80
Percentage Humidity.	49%	.....	100%	35%
Dew-point F.	.....	.....	50.5	50.5
Quality	0.015175	0.015175	0.007767	0.007767
Enthalpy	58.69	41.07	40.93	48.09
Volume	14.16	.....	.....	13.74

Therefore, the refrigeration required is $58.69 - 41.07 = 17.63$ Btu/lb dry air, the heat added from the reheater is $48.09 - 40.93 = 7.16$ Btu/lb dry air, and the moisture removed by the eliminator is $0.015175 - 0.007767 = 0.007408$ lb/lb dry air.

Code Conference Called

The Code Authorities of nearly 300 industries have registered 1,200 delegates to the national code conference to be conducted in Washington, D. C., March 5 to 8 under auspices of the N. R. A. Such a showing in advance is interpreted by the National Recovery Administration officials as indicating that American industry is preparing to take full advantage of the opportunity given it to come to Washington and tell freely and openly what it thinks about N. R. A. codes now in operation.

A gratifying response is reported from the some 200 Code Committees of industries whose codes have passed the public hearing stage but have not yet been approved. Also, written criticisms and suggestions are piling up at the N. R. A. in response to General Hugh S. Johnson's request over the radio that those who find it impossible to come to Washington in person participate in the code conference, and the preliminary public meetings on N. R. A., by letter or telegram. More than 250 specific suggestions for changes in codes or N. R. A. policy have already been received. They are now being analyzed and a summary will be placed in the hands of the chairmen of the appropriate public group meetings.

Corrosion Studies in Steam Heating Systems

This paper is the result of research conducted at the Michigan College of Mining and Technology in cooperation with the A. S. H. V. E. Research Laboratory

By **R. R. Seeber,[1] F. A. Rohrman[2] and G. E. Smedberg[3]** *(NON-MEMBERS)*

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THIS paper presents the progress made to date on the investigation of the relationship of oxygen, carbon dioxide, pH value and method of operation on the corrosive properties of condensate in steam heating systems. Previous attempts have been made to determine these factors in a regular plant, but it was deemed necessary to devise a laboratory set-up in which these variable factors could be controlled to a certain degree and be determined accurately.

With the cooperation of the Technical Advisory Committee on Corrosion of this Society and of the Corrosion Committee of the *National District Heating Association,* both of which are under the chairmanship of J. H. Walker, a set-up of this type was designed and erected at the Michigan College of Mining and Technology. It is an elementary heating system, containing one radiator with supply and return piping and with means for measuring the corrosiveness of the conditions at different points when the system is operated in various ways. The variable conditions which will first be studied are:

1. Constant pressure on radiator, vary vacuum on return.
2. Various pressures throughout system. (20 in.-2 lb gage.)

The description of the apparatus is as follows. The steam is generated in a 66-gal vertical boiler, by means of two immersion type electric heaters having variable heating ranges. (See Fig. 1.) The pressure or vacuum in the system is controlled by a thermostat located on top of the boiler and operated through a relay for opening or closing the circuit to the heaters as the pressure varies, and by means of a vacuum control on the top of the receiver for opening and closing the circuit of the vacuum pump. From the boiler, the steam flows through two "corrosion loops," a 40-sq ft radiator, and two more "corrosion loops," and then to a 16-gal receiver. When the receiver is three-quarters full, a float switch in the receiver turns on a water pump and the condensate is forced back to the boiler. When the water level falls to the half-mark, the switch turns off the pump. This pump is by-passed and used only when the return line is operating under a vacuum. Packless valves are employed above the water line in order to eliminate infiltration of atmospheric gases. Fig. 2 shows a complete plan of the apparatus.

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Oxygen, carbon dioxide, air or other gases can be bled into the system through special fittings located on the water feeder line. In this way a variation in the amount of oxygen and carbon dioxide can be obtained.

The corrosion testers used in each of the four loops are the type devised and recommended by the *National District Heating Association.* Fig. 3 shows the method of installation of these testers and also the type which was designed at the Michigan College of Mining and Technology, which is to be used later. The *N. D. H. A.* testers consist of three helical coils of 0.05 in. diameter

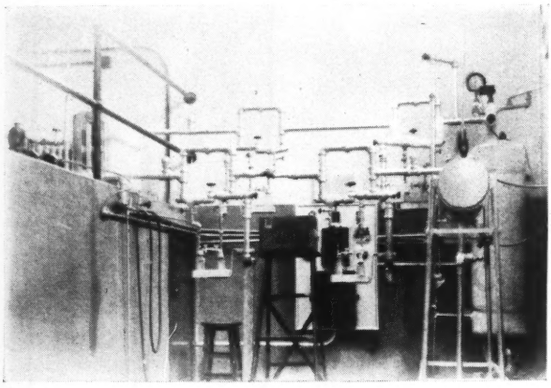

Fig. 1—Apparatus used to generate steam

Bessemer steel wire suspended on an insulating frame. The M. C. M. & T. tester consists of a pipe section which fits into the union of the loop. The testers are first weighed and then placed into the apparatus for the required period of time, after which they are removed and cleaned of their products of corrosion by boiling in a mixture of sodium hydroxide and powdered zinc. They are then washed, dried in acetone, and re-weighed. From the loss the corrosion rate is calculated from the following formula:[4]

$$R = \frac{A}{B \times C}$$

where

R = the corrosion rate as average penetration in inches per year.
A = the loss in weight in pounds per square inch.
B = weight of metal in pounds per cubic inch.
C = duration of test in years.

[4]Formulas by *N. D. H. A.*

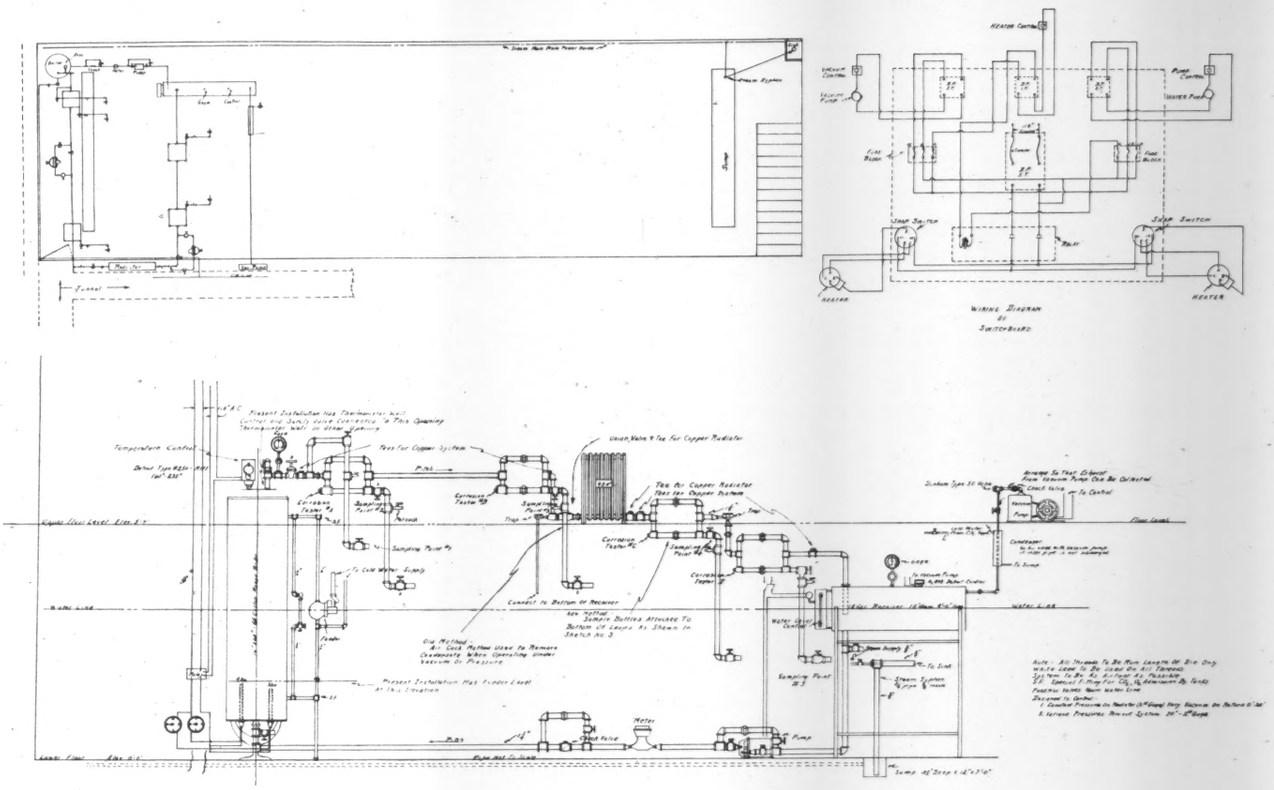

Fig. 2—Complete diagram of apparatus

However, if the corrosion rate is very high, a formula which considers the correction necessary for the reduction in area exposed to corrosion as the process proceeds is used. This correction must be taken into account with corrosion rates greater than 0.02 in. per year. The formula is as follows:

$$R = \frac{D}{2T}\left[\frac{W_1 - W_2}{W_1 + \sqrt{W_1 W_2}}\right]$$

in which

R = corrosion rate, inches penetration per year.
D = original diameter of wire, inches (0.05).
T = time of exposure, years.
W_1 = initial weight of wire.
W_2 = final weight of wire.

The difficult part of this investigation is to obtain a representative sample of water from each of the respective loops, and after obtaining it to keep it in this condition until the analysis is completed. The first method used was to fill each of the vertical pipe sections attached to each loop with nitrogen by means of the petcock, leaving the lower valve open until all the air contained was forced out. (See Fig. 4.) The lower valve and the petcock were then closed and the upper valve opened so that the condensate flowed into the pipe section. The upper valve was then closed and a nitrogen-filled Erlenmeyer flask was placed under the lower valve, the petcock opened, and the condensate forced into the flask to overflowing by the nitrogen pressure and then tightly stoppered. This method was considered to have a tendency to possibly force some of the gases out of solution because of the high partial pressure of the gas, and the nitrogen would gain access to the system. In the second method used, the condensate samples were removed by forcing out any water left in the pipe section by means of nitrogen gas and the section evacuated by means of a water siphon attached to the petcock. The petcock was then closed and the upper valve opened, allowing the condensate to fill the pipe section. The nitrogen-filled bottle was then placed under the lower valve and the upper and lower valves opened so that the pressure of the system forced the condensate sample out. This method could only be used under pressure conditions and also had some danger of the oxygen leaving the solution as it entered the evacuated pipe section. After these two attempts, and at the suggestion of Chairman J. H. Walker, it was deemed advisable to place the bottles for the collection of the condensate in the line and remove them when they were to be analyzed for oxygen, carbon dioxide, and pH value. (See Fig. 5.) This figure shows the method of attaching the bottles to the "corrosion loops" and also a description of the method of operation. For convenience, the method of operation is repeated here:

Bottles H and I are attached to the loops as shown. Stopcocks D, E, F, and G are opened. Hose from water suction is attached to petcock J. Bottle train is evacuated and petcock J closed. Valve A is closed or partially closed, depending on which operated better during the test. Valves C and B then opened slowly, permitting the glass to rise in temperature slowly. Bottles are filled with the condensate. Valve A then opened. Valves and stopcocks B, C, D, E, F, and G are then closed. Bottle group then removed by disconnecting of points 1 and 2. Bottle group then removed through trap door in bottom of bottle stand. The two bottles are separated from each other at point K. They are then placed in cooling vat and cooled to 20 C. The $MgSO_4$, KI,

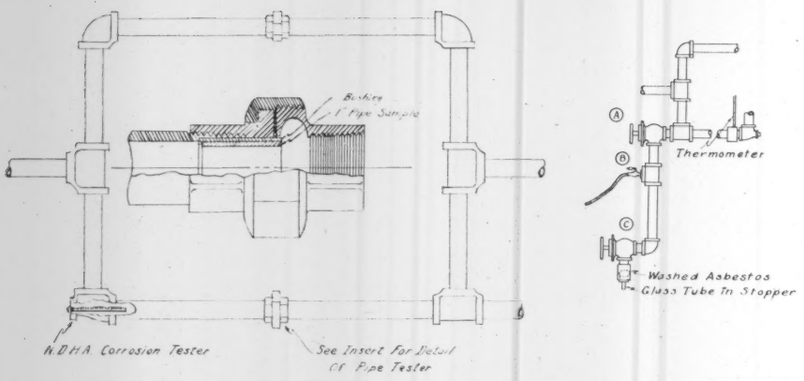

Fig. 3—Method of installing testers in corrosion apparatus

Fig. 4—Apparatus used to obtain samples of condensate for analysis

Method No. 1—With valve *A* closed and *C* open the pipe section is filled with nitrogen gas through petcock *B*. Valve *C* closed and also petcock *B*. Valve *A* opened and condensate flows into pipe section. Valve *A* closed. Nitrogen-filled bottle placed under valve *C*, petcock *B* opened, also *C*. Nitrogen gas forces condensate into bottle. Bottle removed and stoppered.

Method No. 2—Valve *A* closed, *C* open. Condensate in loop from last test forced out by nitrogen gas from petcock *B*. Valve *C* and petcock *B* closed. Hose from water suction pump attached to *B* and pipe section evacuated. Petcock *B* closed and valve *A* opened. Condensate flows into pipe section. Nitrogen-filled bottle placed under valve *C* and *C* opened. Pressure of system forces condensate into bottle. When filled, bottle is removed and stoppered.

and H_2SO_4 are added to the 250 cc bottle (H) by means of the stopcock D, opening E slightly if necessary. Stopper is then removed from bottle H and quantity reduced to 200 cc and the starch solution added. Then titrated with $Na_2S_2O_3$ to end point. Sufficient condensate is withdrawn from bottle I by opening stopcocks G and F so that 100 cc remains. This amount withdrawn is analyzed immediately for pH value. To the 100 cc remaining in the bottle I is added 25 cc $Ba(OH)_2$ solution to stopcock G. Stopper then removed and phenolphthalein solution added. Titrate to end point with HCl acid.

As explained on this diagram the analysis is carried on under the most exacting conditions. All the reagents are added through the stopcocks and the possibility of air contamination is very small. In all previous tests the analysis was determined every day during the test. During the present test, the analysis has been run every other day and the condensate permitted to flow through the bottles for a period of three hours before removal. This is done to prevent any discrepancy due to the bottles being filled with air when installed in the system. After the bottles are removed they are cooled to 20 C before analysis is begun.

Since it was necessary to use rubber stoppers in the bottles, the question arose whether the use of this type of stopper would cause any contamination. A series of tests were conducted which showed that the possibility from this source was not a factor.

Up to the present time we have completed twelve tests of one week duration each. The present test is of three weeks duration. In the first eleven tests the condensate was withdrawn by methods one and two, that is, the first five tests by method one and the remainder by method two. In test number twelve and the present test, the method using the bottles attached to the loops was used. The first tests, although of short duration, helped to point out the discrepancies in the method of withdrawal of the condensate samples. Curves were plotted which showed that the oxygen concentrations obtained were not constant for constant corrosion rates.

This method of analysis with the corrections necessary for the gases in the reagents used will, in our opinion, give accurate, representative results, and, having developed test methods and technique of operation the progress of the work will now go forward with more rapidity.

The main purpose of this progress report is to invite criticism and the authors will appreciate any helpful suggestions relating to this study.

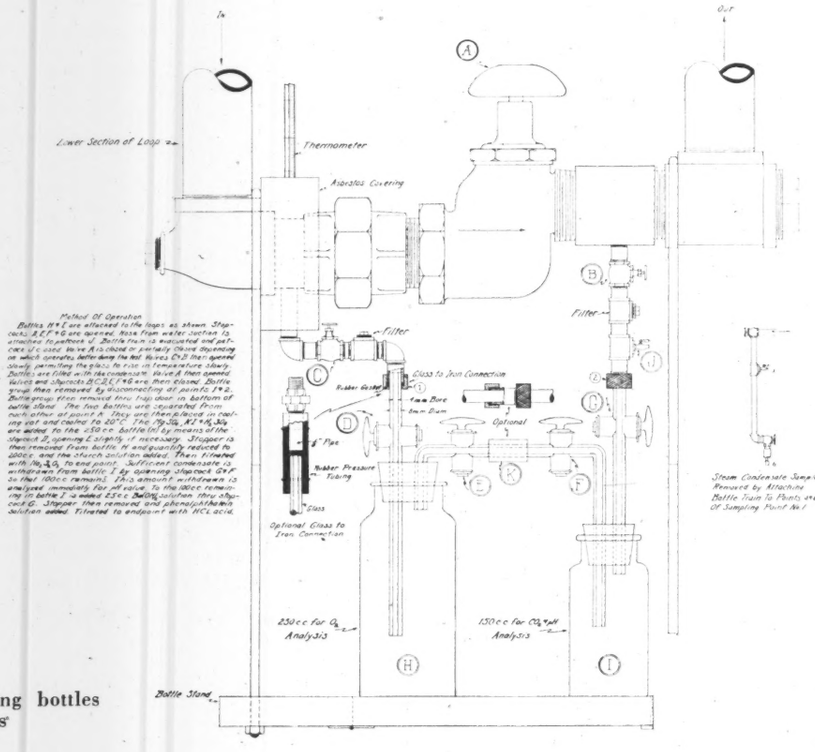

Fig. 5—Method of attaching bottles to corrosion loops

Design and Equipment of the Pierce Laboratory*

By C.-E. A. Winslow,[a] Leonard Greenburg[b] *(MEMBERS)*, L. P. Herrington[b] *(NON-MEMBER)*, and H. G. Ullman[c] *(MEMBER)*

General Objectives

THE John B. Pierce Foundation was established under the will of the late John B. Pierce and as specified in the will, the object of this Foundation "shall be for the promotion of research, educational, technical or scientific work in the general field of heating, ventilation and sanitation for the increase of knowledge to the end that the general hygiene and comfort of human beings and their habitations may be advanced." The Foundation officers are Clarence M. Woolley, president; Rolland J. Hamilton, vice-president, and Henry L. Weimer, secretary and treasurer. For nearly two years work has been in progress on the design and construction of a laboratory for researches relating to the physiological effects of various atmospheric conditions, particularly those due to radiation of various types and electrically charged particles. The Laboratory of Hygiene was formally opened on November 4, 1933. While an independent institution, it will be operated in affiliation with the Department of Public Health of the Yale School of Medicine, under the direction of the senior author.

Since the approach must be a broad one, primarily from the standpoint of human health and comfort, the staff has been so organized that medicine, physiology, and psychology, as well as engineering and physics, are represented by competent experts.

The building (Fig. 1) is situated at 290 Congress Ave., New Haven, in immediate proximity to the Yale Medical School. It is a two-story brick structure, with basement, occupying a total ground area of approximately 1,800 sq ft. In general, the basement is occupied by air-conditioning machinery and animal rooms; the first floor by air-conditioning machinery, workshop and offices; and the second floor by test rooms and a laboratory.

Test House

The heart of the installation is a two-room frame house completely surrounded, above and below and on all four sides, by shell spaces. In these shell spaces any desired conditions of temperature and humidity can be produced. The location of shell spaces and experimental rooms is indicated in Fig. 2 (the second floor plan) and in Fig. 3.

The plant is, of course, designed somewhat along the lines of the laboratories of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, at the United States Bureau of Mines, Pittsburgh;[1] of the American Radiator Co. at Yonkers,[2] and of the University of Illinois.[3] The chief differences are, that the air-conditioning of the shell space is more elaborate at New Haven than at Urbana or Yonkers; that the test rooms are of standard size and ordinary home construction, furnished in such a way as to promote normal psychological conditions in the subjects studied, and forming a suite which can be used for long-time tests on subjects in continuous residence for weeks; and that the facilities for automatic records of both physical and physiological reactions are unusually complete.

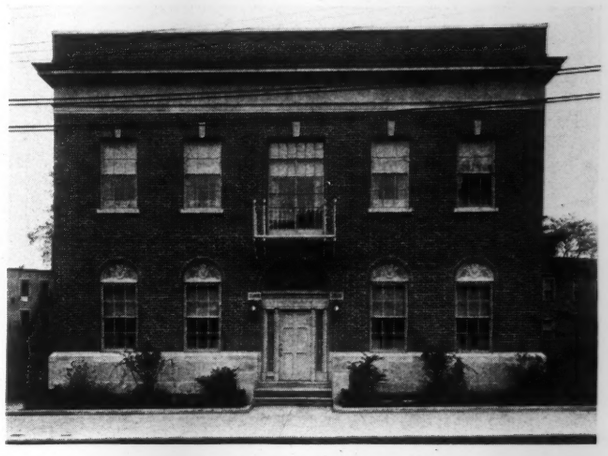

Fig. 1—The Pierce Laboratory

The interior building containing the test rooms in which studies are to be actually conducted is of standard frame construction. It is 29 ft wide and 16 ft deep and includes two rooms, each 15 ft by 12 ft by 9 ft high,[4] separated by a corridor 4 ft wide. This corridor includes first an entrance lobby about 4 ft square. As one enters this lobby through a door from the front shell space, doors open on either side into the two test rooms. A fourth door opposite opens into a toilet room, 4 ft by 3 ft, behind which is a storage room 8 ft by 4 ft. The lobby and toilet room can thus be combined with either test room or with both to form a suite for experiments

*Contribution No. 1, John B. Pierce Laboratory of Hygiene.

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[c]Consultant.

Presented at the 40th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, New York, N. Y., February, 1934.

[1]Houghten, F. C. A Study of Heat Transmission with Special Reference to Building Materials. TRANS. A. S. H. V. E., Vol. 28, 1922, p. 51; McConnell, W. J., and Houghten, F. C. Some Physiological Reactions to High Temperature and Humidities. TRANS. A. S. H. V. E., Vol. 29, 1923, p. 129; Houghten, F. C., and Yagloglou, C. P. Determining Lines of Equal Comfort. TRANS. A. S. H. V. E., Vol. 29, 1923, p. 163.

[2]Brabbée, C. W. The Heating Effect of Radiators. TRANS. A. S. H. V. E., Vol. 32, 1926, p. 11.

[3]Willard, A. C., Kratz, A. P., Fahnestock, M. K., and Konzo, S. Investigation of Heating Rooms with Direct Steam Radiators Equipped with Enclosures and Shields. TRANS. A. S. H. V. E., Vol. 35, 1929, p. 77.

[4]It will be noted that the test rooms are of the standard dimensions prescribed in the Code for Testing Radiators, adopted by the A. S. H. V. E., January, 1927.

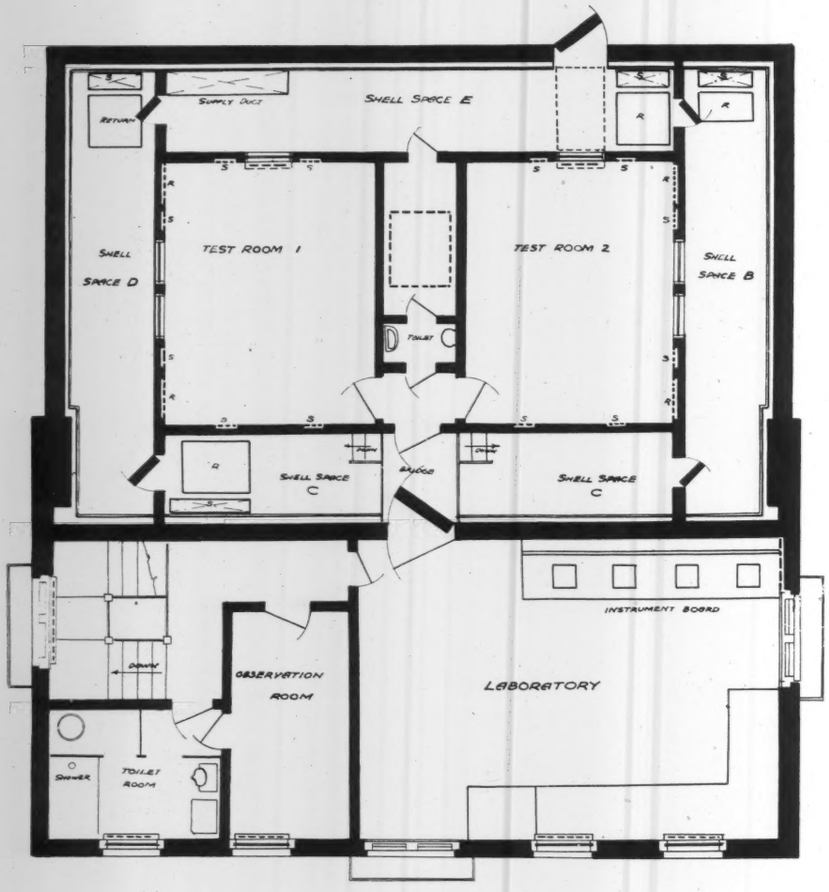


Fig. 2—Plan of second floor

in which subjects are to be kept under specified conditions for days or weeks. The walls separating the corridor from the test room are of wood lath and plaster. Above test rooms and corridor is an attic space 23 in. high with a flat roof of boards covered with tar paper, separating it from the upper shell space.

Control of Shell Spaces

The six shell spaces are all insulated on the outside by laminated cork of standard construction and are separated from each other by walls of Portland cement and cork. Entrance to all the shell spaces is through standard refrigerator doors, 6 in. in thickness.

The temperature and humidity in each of the six shell spaces is independently controlled by conditioned air, supplied as follows:

Shell space A (over the roof of the test house) is 35 in. high. It is divided into three areas, by walls of Portland cement, plaster and cork, running from front to back over the partitions between the two test rooms and the central corridor. (See Fig. 3). Conditioned air is introduced either into space A^1 (over the left room) or space A^2 (over the right room) or into both at once, through a single duct 12 in. x 36 in. which branches to two separate ducts, each 8 in. x 36 in., supplying either half of the upper shell space. Air leaves A^1 and A^2 by the space above the corridor which is used as a return duct. Thus, it is possible to maintain either space A^1 or A^2 or both at a given condition. If conditioned air is supplied to one of these upper shell spaces only, the other cannot be controlled but is left to adjust itself to a value between that of the room below and that of the outdoor air.

The shell space under the floor of the test rooms and corridor is 25 in. high. Otherwise it is divided and controlled in a manner exactly analogous to the ceiling shell space. Shell space F^1 is under test room 1 at the left as one enters; shell space F^2 under test room 2 at the right.

The four lateral shell spaces, B at the right-hand wall of test room 2, C in front of the entire test house, D at the left of test room 1, and E in the rear of the entire test house, are all between 51 and 55 in. wide and all independently controlled by conditioned air. (See Fig. 2). The air enters from a ceiling supply duct extending the entire length of each shell space and perforated throughout its length with 1-inch holes. Air leaves each shell space through a floor grille 3 ft square located at one end.

The exhaust ducts from shell spaces B, C, D and E lead to four separate conditioning chambers. A and F are on the same main supply and exhaust ducts connecting with a fifth conditioning chamber. Thus, either the ceiling or the floor shell space or both, can be maintained at a given temperature and humidity. If one only is controlled the other may be shut off and allowed to adjust itself to the temperature of adjacent areas.

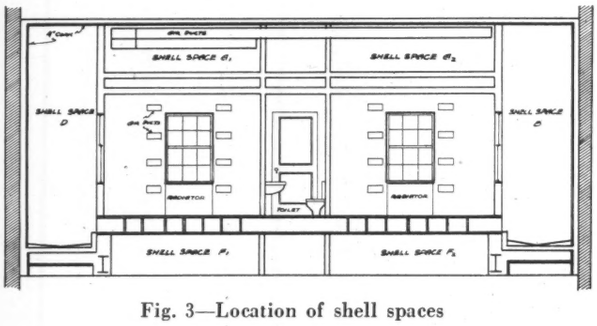


Fig. 3—Location of shell spaces

The five conditioning chambers are all alike, and each includes a dry-coil refrigerating unit of ample capacity; and a spray chamber for humidification. The refrigerating unit is a standard ammonia compressor. The spray chamber has four spray nozzles provided with recirculated water by a centrifugal pump and a small steam heating unit for raising the temperature of the water.

After leaving the conditioning chamber the air passes to the vertical supply duct in which is located the air heater. This is of fin-type construction with approximately 80 sq ft of steam-radiation capacity.

Dry-bulb temperature is controlled by steam valves governed by thermostats located in the return air ducts. As heat is called for in the shell spaces, one or both of two steam valves connected with the air heater will automatically open. As refrigeration is required, these steam valves automatically close and the ammonia compressor is started at a speed corresponding to the load requirements.

Humidity is controlled by humidostats located in the return air ducts, and governing the temperature of the spray water and the proportion of recirculated air which passes through the spray chamber. When an increase of humidity is desired a larger proportion of air is passed through the spray chamber and the steam supply to the water heater is increased. When a decrease is called for, a larger proportion of the recirculating air is bypassed around the spray chamber and the remainder of the air is dehumidified by passing through the refrigerating unit.

The five conditioning units for the shell spaces are located in the basement and are shown in Fig. 6.

The designers of this equipment guarantee in any part of the shell space a minimum average dry-bulb temperature of 0 F, plus or minus 0.5 F, with a maximum summer outside atmospheric temperature not over 90 F dry-bulb and 75 F wet bulb and with inside test room temperature not over 85 F. They also guarantee dew-point temperatures from 40 to 95 F, the maximum variation in wet-bulb temperature at the point of control to be not over 0.5 plus or minus. This latter guarantee covers the dry-bulb range from 50 to 100 F, and will hold regardless of outside temperature and humidity conditions.

The Test Rooms

The test rooms themselves, as pointed out before, are two in number, each 15 ft by 12 ft by 9 ft high. Each room has two windows opening on the end shell space and one window opening on the rear shell space. Outdoor scenes are painted on drops hung on the wall of the shell space outside each window. Each room is provided with the following facilities for heating and ventilation, which can be used separately or in combination:

A. *Direct Steam Heating.* Each room is provided with two steam radiators placed under the windows. These radiators are of cast iron column type and can be set either as free standing or concealed radiators. Provisions have also been made for using a hot-water system of heating if desired.

B. *Radiation.* Special electrical outlets are provided for the operation of radiant panel heaters and certain special heaters of this type have been designed for our experimental purposes. In addition, it is possible by heating a given shell space to a high temperature to use ceiling, floor or one wall as a low-temperature radiant-heating unit.

C. *Indirect Heating.* Conditioned air may be supplied to each room by any or all of six different supply ducts. Two of these ducts run up the front, rear and end wall of each room. (Fig. 2). Each duct opens into the room by five wall registers (each 9 in. x 13 in.) at different levels. (Fig. 3). The center of the upper register is 12 in. below the ceiling and that of the lowest, 6 in. from the floor. It is possible, by manipulation of dampers, to introduce air at any desired level on one or all of three sides of the room in order to study physiological reactions to temperatures at different levels.

Two outlet grilles (6 in. x 27 in.) are located on the side wall at the floor of each room. They connect by means of return air ducts with the test-room conditioning-plant on the first floor. This is a commercial type forced-air heating unit of small size with the addition of refrigerating coils and a water jet for humidification. It was thought best to use simple commercial-type apparatus in this case in order to make the tests as practical as possible. This part of the plant will be more fully discussed in a later paragraph. If more exact regulation of test-room humidities than this equipment permits should be desired, cross-connections can be made with one of the shell space units.

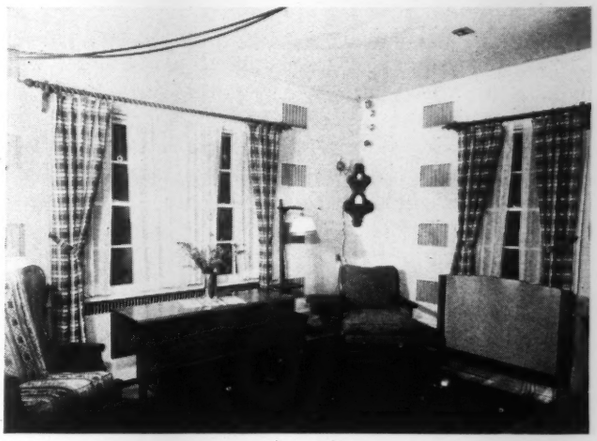


Fig. 4—Corner of test room

D. *Gravity Exhaust.* In the ceiling of each test room is a register (20 in. square) connecting with a gravity-exhaust duct passing up through shell space *A* and the roof of the laboratory building to the outside.

E. *Gravity Supply of Outdoor Air.* In test room 2 (but not in test room 1) provision is made for a supply of fresh and untreated outside air for comparison with various forms of conditioned air. Opposite the lower half of the rear window is an opening about 30 in. square through the outer wall of the rear shell space to the outer air. (See Fig. 2). Ordinarily this opening is closed by a refrigerator door. When untreated outdoor air is desired, an insulated section of 30-in. duct can be let down from the ceiling of the shell space to connect the opening in the outer wall of the shell space with the lower half of the window in the test room. With this section of duct in place and with the outer refrigerator door and the lower half of the window open, outdoor air may enter by gravity, passing only through about 5 ft of a 30-in. square duct which should not materially alter its properties.

The test rooms are lighted electrically by four wall brackets and four standing lamps and are furnished as attractively as possible with rugs and hangings, and household furniture. Each room contains a couch-bed (which can be supplemented by cots if long-continued residence of several persons is desired), a desk, a large table and comfortable chairs. Fig. 4 shows a corner of one of the rooms.

Apparatus for Control and Automatic Records

In the laboratory on the second floor adjacent to the test rooms (see Fig. 2) is a large panel board. One-half of this panel board is occupied by remote-control switches which govern the air-conditioning equipment for the shell spaces. One set of five switches controls dry-bulb temperatures, another set of five switches, the wet-bulb temperatures. The conditions in the return duct from each shell space are recorded in the form of dry-bulb and wet-bulb temperatures registered continuously on two multiple-point recorders, one for the dry-bulb and one for the wet-bulb temperatures.

Air conditions in the test rooms are governed by thermostats and humidostats placed on the wall near the door of each room. Very complete provision is made for recording dry-bulb temperatures (of atmosphere, walls or subjects as desired) and of wet-bulb temperatures of the air of the test rooms. A terminal board concealed behind a hinged bookcase on one wall of each room contains connections for 51 pairs of wires which will terminate in thermo-couples to be placed at the sites whose temperatures are to be recorded. From the terminal board the wires pass through the wall to the panel board in the laboratory. Here 32 pairs of wires from each room are connected to bus-bars from which these paired wires lead to 16-point continuous recorders. The other 19 pairs of wires from each room lead directly to a switch box wired in series with a potentiometer so that the E. M. F. may be read directly. In addition, the bus-bars previously mentioned are so wired that the E. M. F. utilized in the automatic recorders may be switched over to the hand-switching set and read on the potentiometer. Some of the thermo-junctions will be equipped with wicks and water feed devices to record humidity.

Outlets are provided in each test room for six resistance thermometers which when connected give continuous records of air temperature in the test rooms. They register on two additional recorders on the panel board table in the laboratory.

Special Laboratory Equipment

The laboratory on the second floor (Fig. 2) has a floor space of approximately 400 sq ft. Besides the control panel board and recording apparatus, it includes laboratory tables, a fume hood, an instrument cabinet and a drawing table. It is equipped with gas, electricity, vacuum and compressed air, and a steam bath.

At one side of the laboratory is set an ionizing apparatus of the type designed by Prof. F. Dessauer of Frankfort, Germany, which is so placed as to deliver ionized air by means of a glass tube passing through the wall into the small observation room adjacent. (Fig. 2). In this room, two subjects at a time, reclining on couches, may breathe the ionized air. A toilet and shower room occupy the remaining corner of this floor.

If it is desired to supply ionized air to the test rooms, this Dessauer apparatus which produces large ions, or a special apparatus yielding small ions, can be moved to the test rooms and the ions introduced directly into the room or into the air supplied to the room through its inlet ducts.

The laboratory equipment includes a portable Dessauer ion-counter for determining the ion content of indoor or outdoor air; a Benedict-Roth basal metabolism machine, kymographs and other usual physiological apparatus.

First Floor

The first floor of the building includes a reception room with a partitioned office for a secretary, two offices

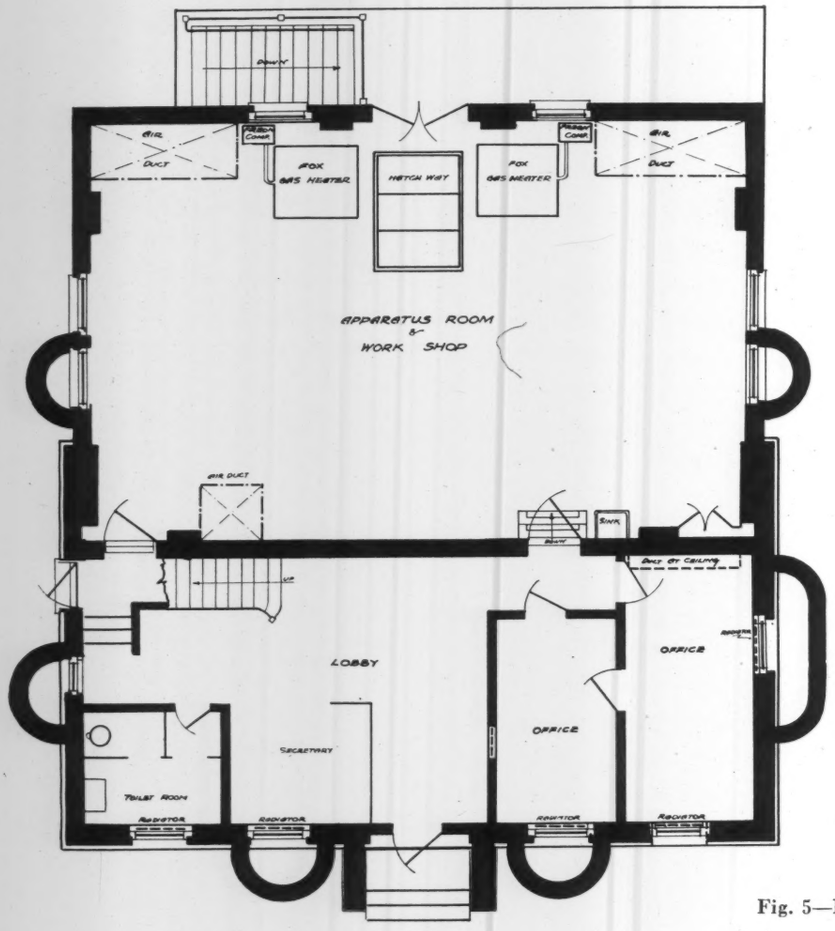


Fig. 5—Plan of first floor

for the director and associate directors, and a large room at the rear. (See Fig. 5). The latter is occupied in part by the air-conditioning apparatus for the two test rooms while the rest serves as a workshop. The workshop is provided with a small machine lathe, a drill-press, a combination circular saw and planer, a band saw and a grinder.

The conditioning equipment for each of the two test rooms includes, as pointed out above, a forced-circulation gas-heating unit in combination with a refrigerating and humidifying unit. Each conditioning chamber is equipped with a variable-speed fan for circulating the air to and from the rooms, and dampers provide for any desired mixture of outside and recirculated air. The refrigerating units are compressors employing dichloro-difluoro-methane as refrigerant. Their capacity is such that both of the test rooms can be cooled to 55 F, when the surrounding shell space is at 90 F. With both compressors connected to one test room, a temperature of 40 F can be maintained in this one room under the above shell-space conditions. Humidification is effected by a small single spray of water controlled by an electrically operated valve.

The Basement

The basement floor is occupied by the equipment for conditioning the shell spaces, and for heating the laboratory building as a whole, and by special rooms for animal experimentation.

A large room in the rear is devoted chiefly to the five conditioning chambers for the shell spaces as shown in Fig. 6. Each of the five units includes the mixing and refrigerating chamber for its respective shell space, and the ammonia compressor which serves it. In the same room is a small electric high-pressure boiler for supplying steam to the laboratory and for sterilizing animal cages. Here also is located the main electric panel board for controlling light and power supplied to all parts of the building.

In the northeast corner of the basement are placed three boilers; an oil burning boiler supplying heat for the building as a whole; a second oil burning boiler providing heat to the conditioning chambers for the shell spaces and to the steam radiators in the test rooms; and a small gas-fired boiler supplying heat to the animal rooms.

The animal rooms themselves are in a special suite constructed of hollow tile. At the west end is an animal stock room, 7½ ft by 8 ft by 10½ ft high. This room is heated by direct radiation and has one outside window. The rest of the suite is occupied by two animal test rooms (each the same size as the stock room) with a smaller air-conditioning room between them. The walls of all these rooms are of hollow tile and the floors of concrete drained to the center. The two animal test rooms are supplied with air which enters near the ceiling and leaves near the floor, by a fan and heating unit in the small air-conditioning room. This unit provides only for tempering the outside air. The air in animal test room 1 can, however, be supplied with completely conditioned air by a cross-connection with the supply ducts to shell space *C*. Special lamps provide ultra-violet radiation since the two animal test rooms have no windows. Special provisions are being made for the introduction of ionized air into one of the test rooms and plugs are provided for radiant panel heating.

It is hoped with this plant as a whole to be able to investigate the reactions of both human beings and animals to a wide variety of atmospheric conditions, particularly those associated with the subtler physical variables, and to study the operation of some of the newer procedures in the field of heating and ventilation in rooms of ordinary dwelling-house construction exposed to fully controlled external weather conditions.

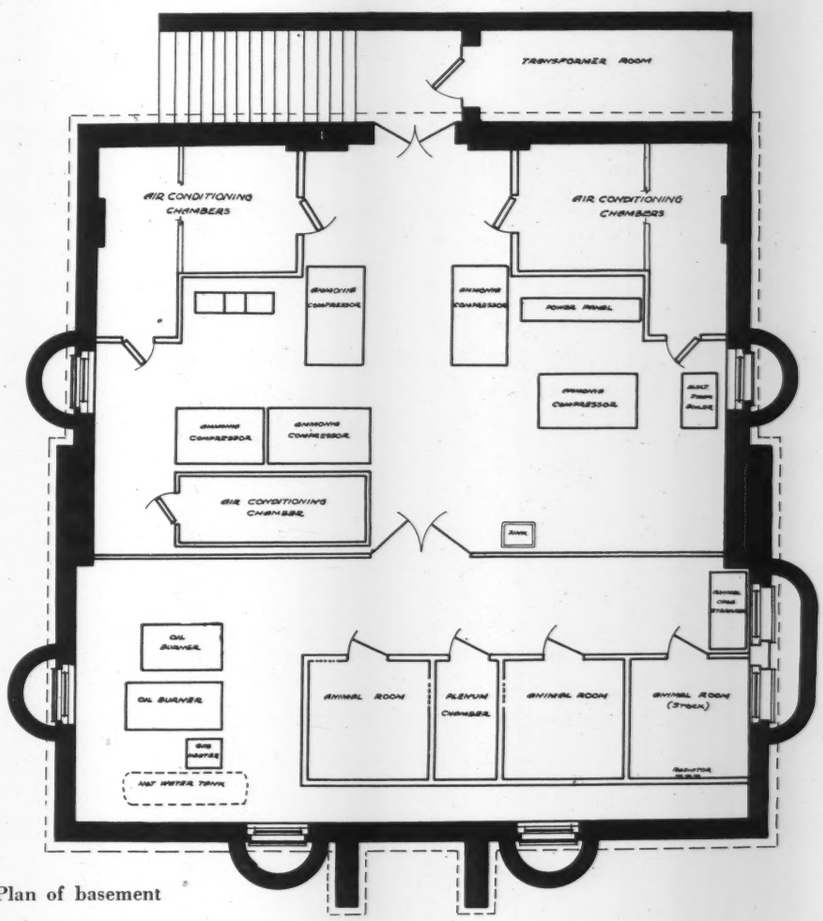
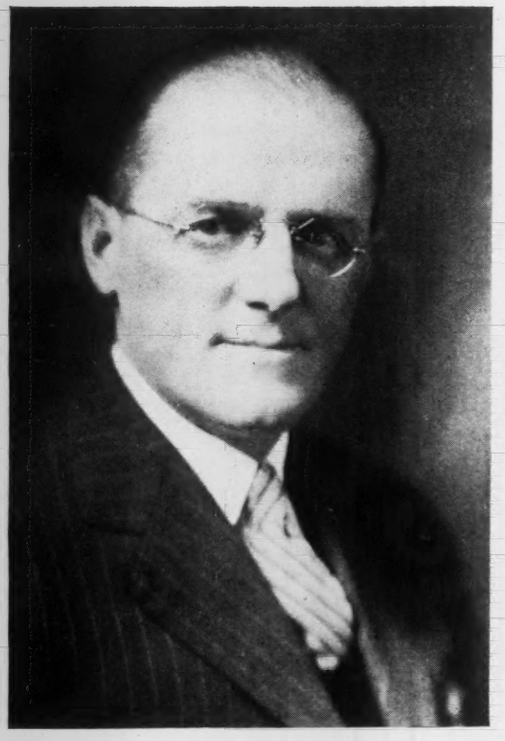


Fig. 6—Plan of basement



W. T. Jones, Boston, Mass.
President—1933

Proceedings of the 40th Annual Meeting

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

New York, N. Y., February 5 to 9, 1934

WITH 650 members, guests and ladies in attendance, the discussion of 20 papers at the six technical sessions and the adoption of the Code for Testing Vacuum Pumps, the 40th Annual Meeting of the Society at Hotel Biltmore from February 5 to 9 was pronounced an outstanding success and a tribute to the New York Chapter members who acted as hosts for the occasion.

The week of February 5 was featured by a splendid Exposition of heating, ventilating and air conditioning equipment at Grand Central Palace, with an audience of 54,000 people during the five days and the meeting of numerous groups of manufacturers. On February 9 a conference to discuss the advisability of creating a basic code for manufacturers of heating, ventilating and air conditioning equipment was considered at a meeting of 200 manufacturers' representatives and code authorities, who were addressed by Beverly S. King, Assistant Deputy Administrator, and Wm. J. Hoff of the Compliance Division of NRA.

FIRST SESSION—

Monday, February 5, 1934, 2:00 P. M.

Pres. W. T. Jones called the 40th Annual Meeting of the Society to order in the Ballroom of the Hotel Biltmore, New York. He announced that on January 26, in accordance with the requirement of the Constitution and By-Laws, a meeting was opened by Vice-Pres. C. V. Haynes in the Hotel Biltmore, but there being no quorum present, adjournment was taken until February 5.

Arthur Ritter, chairman of the Committee on Arrangements, greeted the members present in behalf of the New York Chapter and President Jones responded briefly.

President Jones then read his report.

Report of President

Since the last Annual Meeting of the Society, I have visited all of the seventeen Chapters, and have met with two groups of members in cities where we do not have Chapters, namely Washington, D. C., and San Francisco, Calif. At all of these meetings I have tried to tell the members about the Status Quo of the Society, and it is very pleasing to me to report that throughout our organization I have found a wholesome interest in the affairs of the Society, and a healthy enthusiasm in support of Society activities. The time is not far distant when Chapters can be established in San Francisco and Washington.

The past year has not been notable for its constructive achievement, but rather, your Officers have pursued a course of planned retrenchment, in an endeavor to carry out a pay as we go policy on a drastically reduced income. Other reports will give the details of membership and finances, and it will be noted that the Society is in a healthy condition, although naturally, some drop in membership is bound to occur in times such as we are passing through.

The reduction of dues to $18.00 combined with an active effort on the part of our members has resulted in a pleasing number of new applications, and I urge continued support of our Membership Committee's efforts so that we may regain not only the former number of members, but materially increase it.

This Society is unique in that it returns to each member more in the form of tangible value than he pays in for dues. This condition is possible due to the willingness of a considerable number of our members to contribute liberally of their time, money and ability to Society activities, and also due to the far-sighted wisdom of some of the splendid men who have served the Society in the past.

This condition can not continue indefinitely on our present basis of membership, and neither should our members expect it to do so. In these unusual times it is proper to expect each Society employee to do a little more and to expect our membership to contribute time and ability for the good of the cause, but when business conditions again approach normal, the Society

may be expected to pay for some of the services now being contributed. That is the day we must look forward to and plan for, and I venture to direct your thoughts along these lines.

According to our By-Laws, on next January first the admission fee of $15.00 is to be restored and our dues are to be $25.00, as formerly. Unless conditions change to an extent not now anticipated, it is my opinion that it will not be practicable to return to the former basis on January 1, 1935, and the present or similar rate of dues will have to be continued for a while longer.

It is not my purpose to inject this troublesome question of amount of dues into this report except in so far as this problem affects the point I have in mind for your consideration.

On the present basis of $18.00 per year dues and with 40% allocated to research, Society activities have to be conducted on $10.80 dues from each member. Obviously this amount is too small for a Society of only about 1,900 members to operate on with our present rather ambitious program, and we shall either have to curtail our activities or else obtain more members. In looking over the field and in talking with members of the Society in various parts of the country, I am convinced that there are at least 2,000 men in the industry who are well qualified for membership who do not now belong to the Society. I would suggest that the biggest problem before this Society is to get these men to join our membership and take their share of responsibility in carrying on the work the Society is doing. This increase in our membership would not only make the Society a more powerful organization, but would enable the Research Laboratory to operate an extensive program without the necessity of soliciting funds outside the Society. It would also mean that the Society could be operated at or near the present scale of dues.

The Membership Committee alone can accomplish this desirable end; the program will require the backing of the entire Society membership. If all our members knew as much about the Society as we who are here do, the task would not be difficult. The problem is worthy the consideration of the Advisory Council.

We frequently hear the statement that Society membership consists principally of salesmen, with a few practicing consulting engineers scattered throughout the country. An analysis of our present membership shows the following divisions by occupations:

Consulting Engineers, Architects and Engineers in their employ	11.5%
Heating, Ventilating Contractors and their Estimators and Engineers	18 %
Sales Engineers	19.4%
College Professors	2.2%
Government and Municipal Engineers	2.5%
Research Engineers	4 %
District Heating and Utilities Engineers	2.5%
Manufacturing Executives	10.8%
District and Branch Managers of Manufacturers	8.5%
Association and Publicity Engineers	2.1%
Students	7 %
Unclassified	11.5%

I am giving this information to correct the misapprehension in the minds of some people regarding the occupations followed by our membership.

The Society is indeed fortunate in having an exceptionally fine group of men on the Council this year. No President has ever been blessed with a better Council than I have had. This Council has had to solve some difficult problems most of which are due to a materially reduced income. A considerable number of our members have found it impossible to pay their dues, which fact combined with the comparatively large reduction in the amount of dues has presented some financial problems which have not been easily solved. Your Finance Committee is to be highly commended for an exceptionally fine piece of work.

In my visits to the various Chapters, I have found that the Society activity in which the members take the most interest is the Research program. It has been a particularly difficult year for the Committee on Research, and this Committee has functioned in a highly creditable manner. Their problem has been similar to that of the Society in that the activities have to be conducted on a budget about 50 per cent of what has been considered normal.

When business conditions are good and Society finances are not a great problem, it is easy to find ways of extending our activities, but when times change and Society finances suffer, it is not so easy to curtail our activities to meet the reduced budget, without sacrificing some activities which past Officers of the Society have achieved. The Society today is in a sound financial condition, due largely to the wise planning of some of the Officers in years gone by. Our structure is built upon a firm foundation, due to the foresight of these men, and they are entitled to our gratitude and appreciation for the heritage they have given us in this Society.

Without vision, without foresight, organizations like ours must inevitably perish. Without worthy conceptions animating our ideals we would drift from easy complacency in our brief years of prosperity, to disorganized despair in the long years of hardship. Let us, therefore, always keep before us the fine ideals of this Society; let us all work to the common end of making this industry a better industry because of our efforts; let us prove ourselves worthy of the great age in which we live, and unite in this Society to strive for constantly higher standards and higher ideals.

Respectfully submitted,

W. T. JONES, *President.*

On motion of H. G. Issertell, seconded by J. D. Cassell, it was voted that the Report of the President be placed in the minutes of the meeting.

The first technical paper, Automatic Controls for Forced-Air Heating Systems, by S. Konzo and A. F. Hubbard, was presented by Mr. Hubbard. (Complete paper published in November, 1933, Journal Section, *Heating, Piping & Air Conditioning.*) It was pointed out that the data were collected in the Research Residence at the University of Illinois at Urbana and with the aid of slides the author described the heating installation and the procedure of investigation.

In the discussion Perry West inquired whether the overall efficiency included both cost of current and fuel and E. K. Campbell asked whether the tests would be applicable if bituminous coal were used. W. W. Timmis requested information on the relative efficiencies of combustion during the short periods of *on* and *off* damper operation. G. H. Turland asked about the intervals of taking flue gas analyses and Roswell Farnham inquired about the difference in cost between continuous and intermittent fan operation.

Replies to the questions were given by Mr. Konzo, who stated that the overall efficiency referred to the fuel consumption: namely, the amount of heat absorbed by the house as compared with the fuel burned in the furnace. In replying to Mr. Campbell, it was stated that with one type of control anthracite, bituminous coal and coke had given satisfactory operation. Replying to the question on the efficiency of short periods of damper operation as compared with long periods, it was found that an installation may have a higher furnace efficiency with short dampering periods but there is a certain theoretical difference and an actual difference as measured by a CO_2 meter.

Flue gas analyses were made in sufficient number to indicate that combustion was quite satisfactory with one type of control and less satisfactory in cases where the damper was operated infrequently.

The relative cost of continuous and intermittent fan operation for a 24-hour period could be judged from the fact that with intermittent operation from 10 to 100 per cent of the electrical consumption of 3.6 kilowatt-hours

used in continuous operation, was required in this particular installation.

The paper, Heating Buildings with Hot Water, by B. F. Burt and S. R. Lewis, was presented in the absence of the authors by H. L. Alt, who gave an abstract prepared by the authors.

W. L. Fleisher questioned the use of the term, *kB,* in view of the Society's acceptance last June of the symbol, *Mb,* and stated his belief that various societies should have the same nomenclature for the same units.

Perry West believed that it was in error to design the pipes for the same loss per foot and stated that they should be designed so that the circuits should have the same total loss in order to get a balance.

F. D. Mensing expressed his pleasure on the presentation of a paper about hot water heating and stated there was a decided increase in interest in this medium of heating and he proposed that further attention be given the subject by the Committee on Research when financial conditions are improved.

H. A. Snow briefly described an experimental installation in his home, where he operated a vapor system of thermostatic traps on radiators for hot water and said that no difficulty had been experienced in heating the house when the thermometer was 17 deg below zero and when the outside temperature was 50 deg above zero.

President Jones called upon the Secretary to read the Report of the Council.

Report of Council

The Council met in Cincinnati, Detroit, Chicago and New York since the last Annual Meeting and because of the small number of meetings much work was carried on through correspondence. The business of the Society was administered by the Council and the group of technical committees appointed by Pres. W. T. Jones were responsible for the meeting programs, production of THE GUIDE and the Code for Testing and Rating Condensation and Vacuum Pumps. The work of other special committees passed on the qualifications of candidates for membership, proposed revisions to the Constitution and By-Laws, reviewed papers offered for publication and aided in strengthening the Society's membership.

In January, 1933, the Council confirmed the appointment of four Council Committees suggested by President Jones and voted the appointment of A. V. Hutchinson as Secretary, selected depositories for Society Funds and adopted the budget for 1933 with an estimated income of $54,924 and an expense of $54,100.

The invitation of the Michigan Chapter to hold the Semi-Annual Meeting, 1933, in Detroit and the invitation of the New York Chapter to have the 40th Annual Meeting, 1934, at New York coincident with the Third International Heating and Ventilating Exposition, were accepted. The petition of students at Carnegie Institute of Technology for a Student Chapter was granted and the application of the New York Chapter to institute the plan of Limited Chapter Membership was approved.

In accordance with the provisions of the By-Laws the Council nominated members to serve on the Committee on Research for a three-year term beginning in 1934 as follows: C. A. Booth, E. K. Campbell, John Howatt, A. J. Nesbitt and J. H. Walker.

New rates for catalog data space in THE GUIDE, 1934, proposed by the Guide Publication Committee and recommended by the Finance Committee were approved and price of THE GUIDE, 1934, for sale to non-members of the Society was set at $5 for single copies.

Exhibits were maintained at the *American Oil Burner Association* meeting, in Chicago, during June with the cooperation of the Illinois Chapter and an exhibit at the meeting of the *American Society for Testing Materials* in Chicago, during the same month, featured the research work of the Society and was in charge of Director Houghten.

In August the Council voted to approve in principle the Code of Fair Competition for the Professional Engineer Division of the Construction Industry and appointed John G. Eadie, consulting engineer of New York, as the Society's representative on the National Control Committee.

In accordance with the By-Law provision the Council authorized the employment of a C. P. A. to audit the Society's Books for 1933 and as required by the By-Laws, set the dues rate for 1934 for Members and Associates at $18, Juniors $10 and Students $3 without Initiation Fees.

Changes in the editorial contract were authorized to provide for any revision in the subscription rate and permission was granted for an assignment of the contract to the Keeney Publishing Co. by Domestic Engineering Co., successors to Engineering Publications, Inc.

The Election and reinstatement of 256 members were confirmed by letter ballot and the routine motions on resignations and cancellations of 411 memberships were adopted. The present status is 1887.

Because of the unauthorized use of copyright reports of the Society, in sales promotion literature and in recently published books, the Council made vigorous protest to those responsible. A proposal for commercial testing was received and careful study of the plan indicated that the idea could not be accepted as it was not in accord with the Society's Constitutions and By-Laws and the Regulations of the Committee on Research.

The program for the Annual Meeting was approved and an exhibit at the Heating and Ventilating Exposition was authorized.

The several Council Committees devoted much time and effort to the business of the Society and this brief report is submitted for consideration of the membership in the belief that the work of the Society's governing body will be of interest.

THE COUNCIL.

F. D. Mensing expressed the opinion that the Council had been placed in the position of having to support the President through the National Recovery Act when the Society was requested to support the movement for a Code for Engineers and had done so, even though the Constitution of the Society does not sanction any type of trade approval. It was Mr. Mensing's opinion that that part of the Constitution should be revised to give the Council greater authority. On motion of Mr. Mensing, properly seconded, it was voted that the Report of the Council be received and filed.

President Jones asked the Secretary to read his report.

Report of Secretary

Under a drastically curtailed budget the activities of the Society in 1933 presented a serious administrative problem. It was necessary to carry on to completion many projects under way prior to the beginning of the year and added to this were increased demands for services of various kinds, including employment, NRA code information and an unusual increase in membership applications. A new application form was prepared and distributed in order to simplify the procedure of election under the provisions of the new Constitution and By-Laws. Copies of the Constitution and By-Laws adopted at the last Annual Meeting were printed and distributed to all members.

Three Codes were completed since the last Annual Meeting and were sent to members, namely, the Code for Testing and Rating Concealed Gravity Type Radiation (Hot Water Section); Code for Testing and Rating Air Cleaning Devices Used

in General Ventilation Work and the Code for Testing and Rating Return Line Vacuum Heating Pumps.

Production of *The Guide*, 1933, required an unusually large amount of time of the headquarters staff because of the size of this volume which presents the largest text section ever compiled.

Under the direction of W. L. Fleisher, 50 men were directly engaged in the preparation of the manuscript for the text. The response of manufacturers was excellent so that the catalog data section is slightly larger than in last year's edition.

Two volumes of TRANSACTIONS are nearly ready for distribution to the membership and as these are two of the largest volumes produced in recent years, they imposed a heavy editorial burden on the headquarters staff as it was necessary to edit manuscript and discussions to meet the budget allowance. It is expected that copies of these two books will be mailed to members who paid dues for the years 1931 and 1932 about March 1.

A factor that stimulated interest in Society activities was President Jones' visits to Chapters. He told the story of the Society and what membership in the organization means so that local membership chairmen reported that the information given by Mr. Jones was very helpful in interesting candidates for membership. Chapters in 17 cities were visited by President Jones. During the year 256 men were elected to membership and the present status is 1,887, consisting of 1,238 Members, 363 Associates, 131 Juniors, 125 Students, 28 Life Members, 2 Honorary Members. Two unusually well-attended meetings were held during the past year, the 39th Annual Meeting in Cincinnati where the Local Chapter acted as hosts, and the Semi-Annual Meeting in Detroit where the Michigan Chapter Members accepted the responsibility for the entertainment of the Society's members and guests. The Committees who were responsible for arranging these meetings worked very hard in making them successful and the Society is indebted for the cooperation of each and every one who served.

Due to the size of the meetings held during the year the volume of publication work was exceptionally large and after suitable subjects had been suggested by the Program Committee, papers were obtained and then were reviewed by the Publication Committee before appearing in the Journal of the Society. Each month the chapter activities were reported through the cooperation of the local secretaries. The headquarters office handled the routine correspondence, recording of minutes of meetings and other duties required by the Constitution and By-Laws.

All of the work has been carried on with a personnel of five people and I am glad to publicly express to the members of the staff my thanks for the extra effort that they have given and the many hours that they have spent without additional compensation in carrying on the work for the benefit of the Society membership.

Respectfully submitted,

A. V. HUTCHINSON, *Secy.*

The Report of the Tellers of Election was given by M. E. Durkee as follows:

Report of Tellers

Your Board of Tellers wishes to report results of the vote for election of Officers and Council and members of the Committee on Research to serve in 1934:

President: C. V. Haynes 372
First Vice-President: John Howatt 375
Second Vice-President: G. L. Larson 373
Treasurer: D. S. Boyden 374
Members of the Council:
(Three Year Term)
M. C. Beman 374
E. H. Gurney 375
O. W. Ott 374
W. A. Russell 374
Members of the Committee on Research:
(Three Year Term)
C. A. Booth 375
E. K. Campbell 375
John Howatt 375
A. J. Nesbitt 375
J. H. Walker 375
Total Ballots Cast 445
Disqualified 70
Qualified Ballots 375

TELLERS OF ELECTION
W. R. EICHBERG, *Chairman,*
G. A. DORNHEIM
M. E. DURKEE

The session adjourned at 4:00 p. m.

SECOND SESSION—
Tuesday, February 6, 1934, 9:30 A. M.

President Jones called the meeting to order and introduced John Howatt, Chairman of the Finance Committee, who reported on the condition of the Society. Mr. Howatt referred to the difficulties encountered in carrying on Society activities during 1933, because of curtailment of revenue and he expressed his pleasure to President Jones for the gracious statement of appreciation that had been given on the work of the Finance Committee.

Report of Finance Committee

If a budget is described as a device whereby the worrying is done before the money is spent rather than after, the description would be a true one if the expenditures only had to be budgeted, but we must prepare a budget of anticipated revenue as well as anticipated expenditures. Therefore, our financial worries of 1933 did not cease with the approval of our budget a year ago, because the anticipated and budgeted revenues were not being obtained. There are three main sources of income for the Society.

Income from the Contract with H. P. A. C.
Income from Guide Advertising and Sales.
Income from Members.

Budgeted revenues were obtained from the H. P. A. C. contract and from THE GUIDE but were not received from members.

The gross revenue to the society fell below our estimates to the extent of $5,047.77. The expenses of the Society were $1,987.54 below the budget, leaving a gap of $3,060.23 between budgeted income and expense. However, the budget provided an apparent surplus or cushion of $2,324.00, leaving a net loss for the year of $736.23.

There are accounts receivable from members dues prior to 1933 totaling $9,617.24 and for 1933 totaling $11,652.00. In setting up the assets of the society as of January 1, 1934, all claims for members dues prior to 1933 have been considered of no value, and 75 per cent of the unpaid dues of 1933 have been considered uncollectible. Therefore, of an unpaid dues account of $21,269.24 but $2,913.00 has been considered collectible and has been set up as revenue for 1934.

A year ago your Finance Committee was authorized to sell $5,000.00 par value bonds of the Wisconsin Power and Light to provide for the salary of a man retained to work on Guide sales and promotion. Because of the low price market prevailing throughout 1933 it was considered unwise to sell bonds of this class at the price obtainable, so they are still held in the reserve funds of the Society.

Securities owned by the Society exclusive of Research Funds as of December 31, 1933, cost $26,781.25 with a market value

of $13,042.00, a depreciation of approximately 50 per cent. Since the beginning of the year, however, the market value of these securities has increased nearly $3,000 and it is confidently expected the market for them will improve considerably in 1934. The monies received from the sale of C. S. P. & L. debentures has been invested in U. S. Government 3⅛ bonds.

The capital account or net worth of the society on January 1, 1933, was $32,823.93. The capital account or net worth of the society on December 31, 1933, was $32,458.10, the shrinkage being due to the loss on the sale of C. S. bonds.

The balance sheet at the beginning of this year shows:

$11,939.99 cash on hand.

$21,887.90 collectible accounts.

$30,721.38 invested assets (at cost).

$4,866.79 other assets and inventories.

Only $455.36 in notes receivable from members for past dues.

$36,781.48 current assets.

And total assets of $69,760.42; against these there are current liabilities of $15,372.77. The financial affairs of the Society are in sound condition with current assets 2.3 times current liabilities.

JOHN HOWATT,
Chairman Finance Committee.

On motion of Prof. G. L. Larson, seconded by Prof. A. C. Willard, the Report of the Finance Committee was approved and made a part of the minutes of the meeting.

President Jones said that one of the most important of Society activities was the Research Laboratory and he paid tribute to the ability of Chairman G. L. Larson, who had solved the problem of operating an extensive research program for the Society on very little money.

Professor Larson then presented the Report of the Committee on Research, and stated that in order to close the gap between actual revenue and the necessary expenses, full cooperation was given by everyone involved and he wished to make public acknowledgment of the fine manner in which those directly affected had met the situation and congratulated the Society on having men who were willing to carry on under the conditions that existed this year. (Report of Committee on Research published in February, 1934, Journal Section, *Heating, Piping & Air Conditioning.*)

Professor Larson spoke of the necessity for curtailing cooperative agreements with universities and said that two new contracts had been made where work was being carried on in the interest of heating and ventilating without cost to the Society.

At the conclusion of the presentation of this report, on motion of Professor Willard, seconded by Mr. Campbell, it was voted that the Report be accepted.

The first technical paper of the session, entitled, Design and Equipment of the Pierce Laboratory, by C.-E. A. Winslow, Leonard Greenburg, L. P. Herrington and H. G. Ullman, was presented by Dr. Winslow in abstract.

The author of the paper, Selecting Temperatures and Wind Velocities for Calculating Heat Losses, P. D. Close, was introduced and, after a brief presentation, comments were offered by Professor Willard and W. L. Fleisher. (Complete paper published in October, 1933, Journal Section, *Heating, Piping & Air Conditioning.*)

Professor Larson took the chair and introduced J. L. Blackshaw, who made his presentation in abstract of the paper, Radiation of Energy Through Glass, by J. L. Blackshaw and F. C. Houghten. (Complete paper published in October, 1933, Journal Section, *Heating, Piping & Air Conditioning.*) Comments on the research work conducted at the Society's Laboratory in Pittsburgh were offered by R. A. Miller and W. W. Shaver.

Chairman Larson then introduced F. C. Houghten, Director of the Society's Research Laboratory, who presented the paper, Studies of Solar Radiation Through Bare and Shaded Windows, by F. C. Houghten, Carl Gutberlet and J. L. Blackshaw. (Complete paper published in February, 1934, Journal Section, *Heating, Piping & Air Conditioning.*) Discussions were given by R. A. Miller, C. M. Ashley, F. D. Mensing and E. C. Evans. Answers to the questions asked were supplied by Mr. Houghten.

President Jones resumed the chair and complimented the Committee on Research for its work and expressed the belief that research was the one activity of the Society in which the greatest number were interested and from which the greatest number had benefited. He stated that in visits to various Chapters, very few had objected that 40 per cent of their dues was allocated to research and stated that only on rare occasions had he heard of a member who believed that the research program should be eliminated under present-day conditions. The Officers had, of course, considered the advisability of discontinuing research, he said, but felt that that procedure would be unwise and that curtailment would be better for a number of reasons. First, the valuable cooperation rendered by the U. S. Government in having the Laboratory at the U. S. Bureau of Mines. At present we must spend only $10,000 a year for research at Pittsburgh and to abandon our Laboratory would probably mean that the present favorable arrangement could not be renewed. It seemed to the Officers and Committees that this privilege should be retained so that every cent paid in by members of the Society for research could be used on fundamental investigations in our own laboratory. The Research Committee is operating an extensive program with very little cost to the Society and for the benefit of those who may feel that research might be discontinued. Pres. Jones said that he wished to point out that if this were done now, it would be very costly to start our program again.

The report of the Committee on Code for Testing and Rating Condensation and Vacuum Pumps was made by Chairman John Howatt.

A.S.H.V.E. STANDARD CODE FOR TESTING AND RATING RETURN LINE LOW VACUUM HEATING PUMPS

COMMITTEE: JOHN HOWATT, CHAIRMAN; W. H. DRISCOLL, L. A. HARDING, F. J. LINSENMEYER

A. OBJECT OF THE CODE

1. The object of the Code is to provide a standard method of testing and rating the air and water capacity of vacuum heating pumps under standard conditions as hereinafter defined.

B. DEFINITIONS

2. A Vacuum Pump for the purpose of this Code shall be construed to mean a return line vacuum pump for steam heating systems with a return vacuum up to 10 inches of mercury.

3. The term Vacuum for the purpose of this Code is construed to mean the difference between the absolute pressure

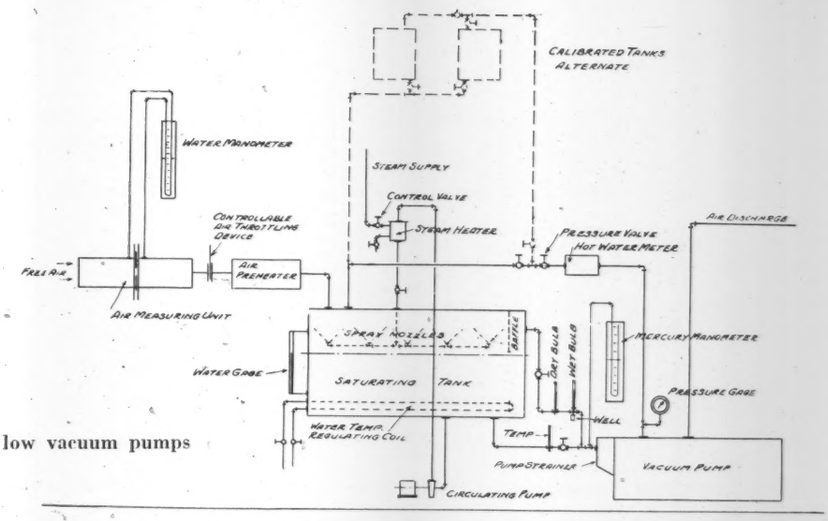


Fig. 1—Test set-up for low vacuum pumps

maintained at the pump inlet connection from the heating system and the absolute pressure of the atmosphere, measured in inches of mercury, referred to standard barometer.

4. Pump Head Pressure is construed as the total pressure head against which the water from the pump is discharged measured in pounds gage pressure in pounds per square inch at the discharge outlet of the pump.

5. Entering temperature is the temperature of the gases and temperature of the water as hereinafter defined measured at the pump inlet connection from the heating system and expressed in degrees F.

6. Standard Air for the purpose of this Code is air weighing 0.0750 lb per cubic foot. This weight corresponds to the weight of dry air at a temperature of plus 70 degrees F and an absolute pressure of 29.92 inches mercury.

7. Horsepower is construed as the brake horsepower supplied to the pump shaft.

C. BASIS OF RATING

8. Rating Factors to be specified. The rating of a vacuum pump shall specify the following:

(1) Maximum capacity of water at 160 deg F in gallons per minute as determined by not less than a twenty minute run after conditions have become stabilized.

(2) Simultaneous capacity of the pump to handle saturated air and water at 160 deg F and at 5½ in. of mercury vacuum, the saturated air expressed in terms of cubic feet per minute at said temperature and vacuum and the water in gallons per minute as determined by not less than a twenty minute run after conditions have become stabilized.

(3) Horsepower input into the pump during the period tests (1) and (2) are being taken. (*Note*: If during the tests the pump is motor driven the motor driving the pump shall be rated in accordance with standards established by the *A. I. E. E.* with allowed corrections for conventional efficiency.)

9. The Standard Basis of Rating is to be the rating for the simultaneous air and water capacity of the unit per minute and the power input when operating under a condition of a vacuum of 5½ in. of mercury at the pump inlet connection to the heating system handling condensate and saturated air at a temperature of 160 deg F and discharging the condensate against a fixed stated head of 20 lb gage.

10. Rating tables for Vacuum Pumps shall contain in tabular form all of the data specified in Par. 8 of this Code.

11. Tolerance. As there are errors in reading instruments of the type used in these tests, a tolerance of plus or minus 2½ per cent will be permitted in test results.

D. METHOD OF TEST

12. The air and vapor capacity of the pump shall be measured by a flange type velocity head flow meter employing a concentric thin plate square edged orifice of non-corrosive material as recommended in the report of the *A. S. M. E.* Special Research Committee, part 2, on Fluid Meters published and accepted by the *A. S. M. E.* in 1931. The meter shall be placed in the test apparatus so it will measure the free air from the room entering the saturating tank. Only approved calibrated meters of approved manufacture shall be used. The 5½ in. of mercury vacuum required to be maintained at the pump inlet shall be controlled by a regulating valve placed between the air meter and the saturating tank.

13. The water capacity of the pump shall be measured by calibrated meters of known accuracy compensated for hot water flow, or calibrated tanks.

14. The partial vacuum under which the pump is operating shall be measured by means of a mercury manometer with one leg of the manometer connected to the suction line on the inlet side of the pump strainer and the other leg of the manometer open to the atmosphere.

15. The drop in pressure across the air measuring orifice shall be measured by a water manometer with the legs connected at opposite sides of the measuring orifice placed in accordance with the requirements of the particular orifice meter used.

16. The temperature of the air and water supply shall separately be obtained by thermometers reading to 1 F inserted in the water line and saturated air line near their junction near the pump inlet.

17. The degree of saturation of the air shall be determined by calibrated wet and dry bulb thermometers reading to 1 F inserted in the saturated air line near the junction of the air and water lines. A suitable water well with wick to mercury bulb shall be provided for the wet bulb thermometer. The relative humidity of the free air shall be determined by wet and dry bulb thermometers.

18. The pressure head against which the pump is to discharge water shall be maintained at a fixed amount by a valve adjusted to maintain 20 or 30 lb as desired. A calibrated pressure gage connected into the pump discharge line near the pump shall be used to determine the discharge pressure.

19. The desired vacuum under which the pump shall operate shall be obtained by a regulating valve on the saturating tank.

E. TEST PROCEDURE

20. Select a measuring orifice of such a size that the drop in pressure through the orifice shall be between 2 in. and 6 in. of water, and install this orifice in the air measuring unit.

21. Select a water meter or calibrated tanks of the proper size for the pump to be tested within the range of calibration for accuracy and install in pump discharge line.

22. Connect up and put in place all measuring instruments as indicated on the diagrammatic sketch of the approved test ar-

rangement, Fig. 1, including calibrated electrical instruments or dynamometer to test the power input to the pump.

23. Adjust the vacuum at the pump, the temperature and flow of the water and air and the pressure head to the values desired. Operate the pump unit for ten minutes under the fixed condition of the test before commencing to take test readings. Maintain conditions constant within plus or minus 1 per cent of the desired values throughout the test run. Read and record all instruments every five minutes for a period of not less than twenty minutes. At the close of the test take the average of the readings for the readings of record.

SAMPLE TEST CALCULATION

Assume average readings on a test run as follows:

Room barometric pressure	29.00 in. mercury
Room air temperature	70 F
Relative humidity of air in rooms	50 per cent
Pump vacuum at inlet	5½ in. mercury
Entering temperature of saturated air to pump	160 F
Orifice differential pressure	2.5 in. of water
Orifice diameter	0.52 in.
Orifice constant	0.602
Pump head gage pressure	20 lb
Coefficient of the Orifice	0.602

To be determined:

The quantity of air handled by the pump measured in cubic feet per minute at 160 F and 5½ in. vacuum.

FORMULA $W = 60\ C\ A \sqrt{2g\ d\ (p_1 - p_2)}$

W = lb per min flowing
C = discharge coefficient
A = area of orifice sq ft.
g = acceleration due to gravity
d = density of air at entering conditions
p_1 = abs. pressure entering orifice pounds per square foot
p_2 = abs. pressure leaving orifice pounds per square foot

To find density of air:

$$\text{Density of vapor } \frac{0.50}{869} = 0.000576 \text{ lb per cu ft}$$

Vapor pressure = 0.7386 × 0.5 = 0.369 in. mercury
Air pressure = 29.000 — 0.369 = 28.631 in. mercury

$$\frac{1}{V} = \frac{p}{RT} = \frac{28.631 \times 0.491 \times 144}{53.3 \times 530} = 0.0717 \text{ lb cu ft}$$

0.0717 + 0.000576 = 0.072276 lb cu ft mixture

$$A = \frac{\pi\ (0.52)^2}{4} \frac{}{144} = 0.00148 \text{ sq ft.}$$

$$p_1 - p_2 = \frac{2.5 \times 144}{2.307 \times 12} = 13.0 \text{ lb sq ft.}$$

$W = 60 \times 0.602 \times 0.00148 \sqrt{64.34 \times 0.072276 \times 13}$
= 0.415 lb per min
cfm = 5.74 entering orifice
Convert to 160 F and 5.5 in. vacuum
29.00 — 5.5 = 23.5 in. absolute entering orifice
9.649 inch mercury vapor pressure at 160 F
23.5 — 9.649 = 13.851 in. partial air pressure entering pump
28.631 inch partial air pressure entering orifice

Hence $5.74 \times \frac{620}{530} \times \frac{28.631}{13.851} = 13.90$ cfm entering pump in saturated condition

It was explained that because of the lack of unanimity of opinion or agreement about the proper conditions of rating or testing condensation and vacuum pumps, purchasers found it difficult to make a comparison of equipment from the engineering data furnished by manufacturers. Therefore, the Society in 1932 felt that a standard code was desirable and a committee was appointed with the following personnel: John Howatt, *chairman*, W. H. Driscoll, L. A. Harding and F. J. Linsenmeyer.

Desiring to prepare a code that would be universally used, the committee invited representatives of manufacturers to confer and this invitation was promptly accepted and generous support and cooperation were given. Work was started seriously in April, 1933, and the present code is one that is acceptable to the Society's committee and in general meets with the approval of the manufacturers of equipment.

Mr. Howatt then explained the objects of the code, gave the definitions which had been adopted and explained the basis of rating and the reason for selecting 160 deg water temperature and 5½ in. of vacuum.

The code was presented for adoption.

The following amendments were presented and approved. C. V. Haynes proposed an amendment to the title, so that it would read:

American Society Heating and Ventilating Engineers Standard Code for Testing and Rating Return Line Low Vacuum Heating Pumps.

He also suggested a change in paragraph 2 of the Definitions, so that it would read:

A Vacuum Pump for the purpose of this Code shall be construed to mean a return line vacuum pump for steam heating systems with a return vacuum up to 10 in. of mercury.

Howell Adams suggested a change in paragraph 8, Section 3, so that it would read as follows:

Horsepower input into the pump during the period when tests (1) and (2) are being taken. Note: If during the test the pump is motor-driven, the motor driving the pump shall be rated in accordance with standards established by the *A. I. E. E.* with allowed corrections for conventional efficiency.

A motion by F. D. Mensing, seconded by Mr. Haynes, provided that paragraph 8, section (1), be amended to require a test run of one hour. After considerable discussion on this point by Messrs. Ashley, Wiley, Howatt and Mensing, on vote the motion was lost.

A vote was then taken on the motion to adopt the code as amended, which was made by C. F. Ames and seconded by Mr. Haynes. Upon passage of this motion, President Jones announced that the code would be submitted to the entire society membership for vote by letter ballot in the manner prescribed by the Constitution and By-Laws.

On motion of Mr. Haynes, seconded by Russell Donnelly, it was voted that the Code Committee be continued and that it be instructed to prepare a test code for return line vacuum pumps in excess of 10 in. of mercury.

The session adjourned at 12:50 p. m.

THIRD SESSION—
Tuesday, February 6, 1934, 2:00 P. M.

Pres. W. T. Jones called the meeting to order and introduced Elliott Harrington, who presented an abstract of his paper, A Proving Home for Air Conditioning Investigations, by E. Harrington and L. A. Mears.

Prof. A. P. Kratz pointed out that the desirable temperature differential between floor and ceiling of approximately one-half degree per foot, which was mentioned by the author, should be accompanied by a statement of the prevailing outdoor temperature, because in the work at the Research Residence at the University of Illinois it was found that a temperature difference between floor and ceiling of 3 deg could be maintained in mild weather, but that the differential was very wide when a zero outdoor temperature was prevailing.

In introducing W. L. Fleisher, chairman of the Guide Publication Committee, President Jones said that the reason the Society was able to return to each member more in tangible value than a member pays in the form

of dues is because many members are contributing time, ability and money for the good of the Society.

Report of Guide Publication Committee

THE GUIDE 1934 is about ready for distribution to the membership and copies will be mailed within the next 10 days. This year THE GUIDE again appears in a flexible red binding and contains 42 chapters of technical data covering 618 pages with all subjects cross-indexed. One hundred manufacturers used catalog data space totaling 176 pages with an Index to Modern Equipment. The first printing was limited to 7500 copies and the income from advertising totals $15,300, and the estimated return from copy sales will be $8500. The cost of THE GUIDE 1934 for printing, distributing and all other services was about $18,500 to date.

The Technical Data Section of this 12th Edition has been enlarged to include newly developed data that are vitally important in meeting the present day demands of engineers who devote their time to heating, ventilating and air conditioning practice. From the practical experience of members as well as from available research sources useful facts have been gathered and incorporated in the 42 chapters which have been arranged for convenient reference. An extensive index has been included to aid the reader. The text is prepared for engineers, architects, contractors and students who are designing, operating, specifying, installing and studying systems and apparatus the functions of which are to create comfort and to improve the efficiency of processing.

For the important work of creating THE GUIDE 1934 the assistance of engineers of specialized training and knowledge was enlisted. The careful reviewing, compiling and editing of data selected from authoritative sources was accomplished through the cooperative efforts of the following men who have unselfishly given of their time and knowledge:

T. Napier Adlam
J. C. Albright
H. L. Alt
C. F. Ames
C. M. Ashley
A. L. Baum
J. L. Blackshaw
C. A. Bulkeley
R. E. Cherne
L. A. Cherry
P. D. Close
R. F. Connell
J. M. DallaValle
Philip Drinker
M. William Ehrlich
John Everetts, Jr.
F. H. Faust
W. G. Frank
R. S. Franklin
F. E. Giesecke
W. C. Goodwin
L. A. Harding
H. M. Hart
F. C. Houghten
L. P. Hynes
R. E. Keyes
V. O. Knudsen
A. P. Kratz
I. W. Kreitner
G. L. Larson
R. D. Madison
J. F. McIntire
H. B. Meller
J. G. Mingle
H. C. Murphy
D. W. Nelson
A. J. Nesbitt
M. E. O'Connell
A. J. Offner
E. C. Rack
F. G. Sedgwick
G. L. Tuve
C. P. Yaglou
John Zink

The Guide Publication Committee is glad to acknowledge the splendid cooperation of these engineers who have served so willingly for the benefit of their associates in the profession. The Society, too, should thank these men for the assistance that they gave the Committee and for the time that they spent in the service of the organization.

Some specific suggestions have been made to the council regarding future handling of THE GUIDE in order that its potentialities may be realized. One particular point however, that might be stressed here is that THE GUIDE provides the most extensive contact with individuals and groups outside of the organization and it has spread the name of the A. S. H. V. E. throughout the world. THE GUIDE has been instrumental also in carrying the results of our Research Laboratory work to thousands outside of our Society membership and it has aided materially in giving up-to-date data on air conditioning which today is about the third most talked of subject in engineering, the others being automobiles and airplanes.

It is the opinion of your Committee that THE GUIDE has unlimited future possibilities and it should be arranged and edited to serve the large group of people who are conscious of and interested in air conditioning. It is hoped that some way funds can be found to do this.

In conclusion I wish to thank the members of the Committee for the support that they have given me in handling the work which was a far bigger job than I had any conception of and to express the hope that when the members see THE GUIDE 1934, that they will find pleasure in using this new volume.

Respectfully submitted,
Guide Publication Committee,
W. L. Fleisher, *Chairman.*

E. H. Gurney expressed the opinion that the Society owed Mr. Fleisher a debt of gratitude for the great service that he had rendered in compiling the book and in visualizing what may be done in the future years and he offered a resolution of thanks to Mr. Fleisher for his service as chairman of the Guide Publication Committee. The motion was seconded by Mr. Mensing and carried.

A paper on Low-Cost Air Conditioning for a Small Residence, by M. K. Drewry, was presented by Prof. G. L. Larson, who gave an abstract which had been prepared by the author. (Complete paper published in January, 1934, Journal Section, *Heating, Piping and Air Conditioning.*)

A paper on Comfort Cooling with Attic Ventilating Fans, by G. B. Helmrich and G. H. Tuttle, was given briefly by Mr. Helmrich. (Complete paper published in February, 1934, Journal Section, *Heating, Piping and Air Conditioning.*) Comments on this paper were offered by J. H. Walker, H. C. Bender, E. K. Campbell and G. E. Olson and the several questions asked were answered by Mr. Helmrich.

A cooperative research paper, reporting the work done at the University of Illinois in cooperation with the Society's Research Laboratory, was presented by Mr. Konzo, in a Study of Summer Cooling in the Research Residence for the Summer of 1933, by A. P. Kratz and S. Konzo. (Complete paper published in December, 1933, Journal Section, *Heating, Piping and Air Conditioning.*)

Supplementing Mr. Konzo's remarks, Professor Kratz showed a curve which had been developed from the data collected, indicating the limiting number of air changes that would be proper in effective cooling.

With the aid of a slide, J. H. Walker presented some comparative figures regarding the operating costs that might be expected under various types of operation. Other comments were offered by Messrs. Helmrich and Everetts and replies to the questions were given by Mr. Konzo.

The meeting adjourned at 4:15 p. m.

FOURTH SESSION—

Wednesday, February 7, 1934, 9:30 A. M.

The fourth session of the Society's Annual Meeting was called to order by President Jones, who introduced the chairman of the Membership Committee, E. K. Campbell, of Kansas City. Mr. Campbell presented his report.

Report of Membership Committee

While there are some encouraging factors in the membership situation your Committee feels there are still many things to be accomplished during the coming year. President Jones was very helpful in his visits to the Chapters and he made definite progress in reselling this organization to its membership. This has been badly needed and some more work along this line must be done. When members are fully sold on their Society, the problem of membership will take care of itself.

It is a true statement that there are thousands of men over the country waiting for an invitation to join the Society and this

is manifest by the many who write into the headquarters office inquiring about the requirements for membership. These men are listed and if the prospect is in Chapter area, notice is sent to the local membership chairman. Where prospects are outside of chapter areas, the Membership Committee follows up the matter.

As the work of the Society becomes better known there are many who feel the urge to join it, and the work of finding eligible men must be done by the rank and file of the membership, as it is impossible for a small Membership Committee, even with the fine cooperation that is given by local chapter membership committees to contact all of the people who would make desirable members.

During 1933, 256 applications were received, of which 84 were from students; 102 resigned and 300 were dropped. There was a net loss of 230 in membership and a corresponding loss of income to the Society.

Student membership in the opinion of your Committee is a good investment and a future asset, but is a present liability. Of the number dropped during the year nearly half should have been canceled in the previous year, but the Council was loath to drop them from the rolls until all efforts to keep them had been exhausted.

It can be seen that this year with only 172 candidates elected to Member, Associate and Junior grades, it is insufficient to keep the Society going and the dues collected from our members now on the rolls, consisting of 1268 Members, 363 Associates, 131 Juniors and 125 students has not paid for the services that they are receiving. Research activities have been particularly hard hit and the amount expended has been reduced about 60% in the past two years. Because of the publications, the Society has continued to maintain much of its usual service to the membership.

As Chairman of the Membership Committee, it is my observation that the average member is indifferent in his national outlook and at this critical time there should be a strenuous effort made to not only resell our membership on the Society but also use some salesmanship in interesting eligible candidates.

Respectfully yours,
Membership Committee,
E. K. Campbell, *Chairman*

President Jones expressed his appreciation to Mr. Campbell for the work his committee had done during the year and said that the average member does not realize that a committee of three from the Council cannot get all of the new members and that the work is really up to the entire membership. He said that it was his hope that each member will bear this fact in mind and help the committee replace the losses which the Society is bound to suffer in times like these.

The paper entitled, Thermodynamic Properties of Moist Air, by Prof. J. A. Goff, was given in abstract by Prof. A. P. Kratz of the University of Illinois. The discussion was opened with Second Vice-President John Howatt in the chair. Comments were offered by Dr. A. A. Adler, D. D. Jacobus and W. L. Fleisher.

Chairman Howatt then introduced Dr. W. J. McConnell, who presented the paper, Study of Air Conditioning and Office Employees Efficiency, by W. J. McConnell and I. B. Kagey.

Speaking from slides, Dr. McConnell gave a description of the air conditioned office building with 28 stories and 4 basements having a floor area of 23 acres and 15,000,000 cu ft of conditioned space. It was pointed out that the system operated about 11 hours a day except in extremely hot weather. A series of charts were shown by Mr. Kagey, giving data for inside and outside temperatures and operating data for some of the hot summer days of 1933.

With President Jones in the chair, Robert D. Williams, president of the *Heating, Piping and Air Conditioning Contractors National Association,* was introduced and he said:

It is a great privilege for me to be here at this time, particularly when I have the opportunity of relaxing from the labors attending the making of a code. Therefore, I am glad and very much interested to bring to you at this time the greetings and best wishes of our National Association for a most successful meeting.

The technical nature of your deliberations are such and are so closely allied with the contracting problems of which our Association is faced, that we naturally look forward with special interest to the presentation of the engineering papers here by men of your training which mean so much to us all.

Therefore, Mr. President, may I say to you that I am indeed happy to again extend to this Society our word of regard and to sincerely hope that the years, and they come and go, will bind more closely together this Society and our Association in sympathy, cooperation and helpfulness.

President Jones responded briefly and then introduced the next paper, Observations of Hay-Fever Sufferers in Air-Conditioned Room and the Relationship Between the Pollen Content of Outdoor Air and Weather Conditions, by T. A. Kendall and Garland Weidner. (Complete paper published in February, 1934, Journal Section, *Heating, Piping and Air Conditioning.*) An abstract of this paper was presented by W. H. Driscoll at the request of Dean F. Paul Anderson, who could not be present because of a recent serious operation.

Comments were offered by H. C. Murphy, C. W. Obert, H. B. Johns, Charles Davies and J. H. Walker.

The paper, Corrosion Studies in Steam Heating Systems, by R. R. Seeber, F. A. Rohrman and G. E. Smedberg, was presented by Professor Seeber. J. H. Walker gave a brief review of previous studies on corrosion in order that the significance of Professor Seeber's work might be better understood Other comments were offered by Dr. A. A. Adler, Prof. G. L. Larson, Mr. Walker and T. M. Dugan.

FIFTH SESSION—

Wednesday, February 7, 1934, 2:00 P. M.

President Jones opened the session and said the first presentation of the afternoon would be the Report of the Publication Committee by W. E. Stark, who said that it seemed hardly necessary to give a detailed report, because each time a paper is read at the meeting it constitutes part of the Publication Committee's report.

Report of Publication Committee

The Publication Committee is composed of three very diligent readers. We are surpassed in our diligence as readers only by the chairman of the Guide Publication Committee, who reads everything that goes into THE GUIDE, and by Mr. Hutchinson, the Secretary, who reads everything that goes into THE GUIDE and every publication as well.

One of the nominal duties of the Publication Committee is the preparation and publication of THE TRANSACTIONS. However, the Publication Committee's work in connection with THE TRANSACTIONS is often more nominal than real, because our very efficient Secretary does all of the work connected with THE TRANSACTIONS. Two volumes, that for the year 1931 and that for the year 1932, are nearly completed and will be sent to members in about a month.

One of the members of the Publication Committee presented a paper this morning, the paper on the Thermodynamics of Air Conditioning, and he stated before he started presentation that he didn't know very much about the thermodynamics of air conditioning, but he was really fooling you a little bit because he got a chance to learn something of the subject when he went over that paper.

The report of the Publication Committee may be summarized for purposes of record. During the year the Committee reviewed a total of 35 papers with the idea of upholding the quality of presentations recorded in THE TRANSACTIONS of the Society and providing technical information of interest and value in useful and concise form. Ten papers were presented at the 1933 Semi-Annual Meeting in Detroit and 20 papers have been scheduled for this New York Annual Meeting of 1934. A few papers were rejected as being unsuitable for Society publication and two were withdrawn.

The paper, Carbon Monoxide Surveys of Two Garages, by A. H. Sluss, E. K. Campbell and L. M. Farber, was given by Professor Sluss as a progress report on the work carried on at the University of Kansas and in Kansas City garages. (Complete paper published in December, 1933, Journal Section, *Heating, Piping and Air Conditioning.*)

A report on another cooperative research project was that of Professor Yaglou, who presented the paper, Diurnal and Seasonal Variations in the Small-Ion Content of Outdoor and Indoor Air, by C. P. Yaglou and L. C. Benjamin. (Complete paper published in January, 1934, Journal Section, *Heating, Piping and Air Conditioning.*)

The discussion was conducted with First Vice-President Haynes in the chair and comments were offered by Dr. C.-E. A. Winslow and Dr. C. A. Mills.

The paper, Air Conditioning in Its Relation to Human Welfare, by Dr. C. A. Mills, was presented by the author. President Jones presided during the discussion and questions were asked by Miss Margaret Ingels, Thornton Lewis, Professor Yaglou, Dr. Winslow, Dr. McConnell, C. S. Leopold, Dr. Adler, W. L. Fleisher and Dr. Greenburg. A detailed reply to the questions was given by Dr. Mills.

The next paper was presented by the author and was entitled, Engineering in the Hospital of Tomorrow, by C. F. Neergaard.

Following an abstract of this paper, the discussions were given by James Govan, Dr. Adler, G. H. Turland, and H. H. Angus.

President Jones said that he was glad to announce a registration of over 500 at the meeting with members and guests from Canada, Oklahoma, Florida and Texas and expressed the belief that Professor Giesecke held the long distance record from College Station, Texas.

President Jones said that one of our members had not registered this year for the first time since the Society was organized in 1895. He attended the 39th Annual Meeting in Cincinnati, left the sessions because of illness, returned home, and in a month his name was removed from our roll of membership and transferred to the celestial society above. This wonderful record of having attended every Annual Meeting of the Society since its inception in 1895 belonged to Andy Edgar of Philadelphia.

The session adjourned until 2:00 p. m. on Thursday.

SIXTH SESSION—

Thursday, February 8, 1934, 2:00 P. M.

The final session of the 40th Annual Meeting was called to order by President Jones who announced that the newly elected officers should be installed.

At the request of President Jones, Thornton Lewis escorted Roswell Farnham one of the retiring Council members to the rostrum. President Jones on behalf of the Society expressed his thanks for the seven years service which had been rendered by Mr. Farnham.

W. H. Driscoll conducted C. V. Haynes, President-elect, to the rostrum and President Jones said that as executive head of the Society for the coming year a great measure of responsibility rests upon your shoulders and because of your familiarity with the organization and the duties to be performed as president and your enthusiasm for the Society, we feel proud to welcome you as President.

First Vice-President John Howatt was conducted to the rostrum by W. H. Driscoll and he was installed by Thornton Lewis.

The Second Vice-President, Prof. G. L. Larson, was escorted to the rostrum by Thornton Lewis for installation by Mr. Driscoll.

The newly elected Council members, who were present, Messrs. Beman, Gurney and Russell, were brought to the rostrum by W. H. Carrier and were installed by Mr. Jones.

The gavel was turned over to President-elect C. V. Haynes, who expressed his pleasure for the honor conferred upon him and then inquired whether any new business was to come before the meeting.

W. R. Eichberg presented a petition signed by the required number of members, proposing an amendment to Article B-VIII, Section 1, of the By-Laws. W. H. Driscoll pointed out that the proposed amendments should take the regular procedure, so that an opportunity might be given to all members to vote for or against it.

Mr. Jones suggested that the resolution be introduced and submitted to the Council for reference to the Committee on Constitution and By-Laws. On motion of Mr. Jones, properly seconded, it was voted unanimously to refer the resolution to the Council.

E. H. Gurney asked the privilege of the floor and said:

Many of us have at one time or another gone to Europe and when we get on the ship in the North River things are beautifully ordered. A John Collins comes regularly in the morning (but I learned in New York it is a Tom Collins); three meals a day are served; there is soup on the deck and a snack at other times; a comfortable bed and sometimes the ship goes through a storm much as the A. S. H. V. E. has experienced. All is well ordered and one does not see the background or know the work, trouble and responsibilities of the captain. As one who has seen intimately the activities of this Society during the past three years, it seems to me appropriate that we pay tribute to the fine leadership that the Society has had in the past year. I have seen several presidents of the A. S. H. V. E. and as Shakespeare said that comparisons are odious, I will not make any. I am sure that we haven't been favored with a better president and no president has ever had a more trying period to carry on Society affairs and I, therefore, move that the sincere thanks of the Society be extended to Past President Jones for his splendid service during the past year.

The motion was seconded and carried by a rising vote.

A cooperative research paper entitled, Study of Fuel Burning Rates and Power Requirements of Oil Burners in Relation to Excess Air, by L. E. Seeley and E. J. Tavanlar, was presented by Professor Seeley.

A written discussion prepared by Prof. D. W. Nelson of the University of Wisconsin was read by Professor Larson. Other comments were offered by W. K. Walker, W. H. Carrier, W. H. Driscoll, Louis Northon, A. A. Adler and E. J. Tavanlar.

Dr. C. W. Brabbée was introduced by President Haynes and gave his paper, Design and Valuation of Cast Iron Domestic Heating Boilers. Discussions were presented by W. H. Carrier and W. L. Fleisher.

W. H. Driscoll was introduced and read the report of Samuel R. Lewis, chairman of the Committee on Nomenclature. A letter from the committee to Mr. Jones was read and Mr. Driscoll pointed out that the Committee on Nomenclature was appointed immediately after the Annual Meeting in Cincinnati to eliminate from our literature the term, *square foot*, and substitute something that would be more accurate and more descriptive. He explained about the animated discussion and correspondence that took place between members of the committee and reviewed the conference of organizations held in Detroit under the auspices of the Society.

At this conference a resolution was adopted to the effect that it was the opinion of those present that the symbols, Mb and Mbh, be adopted and it was agreed that the representatives of the various organizations would go back to their respective societies and endeavor to have them adopt the proposed symbols. On the following day, the Society in session at Detroit approved the symbols proposed by the Committee on Nomenclature, Mb to express 1000 Btu and Mbh to express 1000 Btu per hour.

Subsequently correspondence came from the *A. S. M. E.* indicating that its representatives at the Detroit meeting were not familiar with some of the previous activities, as an *A. S. M. E.* committee had recommended the use of *kB* to express 1000 Btu. After some correspondence, the committee has decided that it might be advisable to adopt the *A. S. M. E.* symbol, but before that can be done, it is necessary to rescind the action taken at the Detroit meeting. If this is done, the next step would be the adoption of a new symbol, so in order to get the matter before the meeting, the following resolution was offered:

Resolved that the Society rescind the action taken at the Semi Annual Meeting, 1933, in Detroit with respect to the adoption of the symbols Mb and Mbh.

The motion was seconded by Mr. Jones.

There was a lively discussion of the motion between Messrs. Fleisher, Gurney, Jones and Driscoll.

A motion to lay the matter on the table, pending the result of the committee's conference with interested organizations, was offered by Mr. Fleisher, seconded by John D. Cassell, and carried by vote of those present.

President Haynes called upon the Secretary to present the Report of the Committee on Revision of Constitution and By-Laws.

Secretary A. V. Hutchinson reported that recommendations of the Committee on Constitution and By-Laws, approved by the Council, had been sent to the membership in accordance with the procedure required by Article B-XVI of the By-Laws. The changes are as follows:

Art. B-IV Sect. 4—Of the annual dues paid by the members of each grade, three dollars ($3.00) shall be considered as a subscription for the Journal of the Society.

To be amended to read—Art. B-IV Sect. 4—Of the annual dues paid by members of each grade, *a sum equal to its current subscription price* shall be considered as a subscription for the Journal of the Society.

Art. B-XI Sect. 6—After December thirty-first, and before the Annual Meeting of the Society in January, the accounts of the Society shall be audited by a certified public accountant, selected by the Council at its last meeting in the calendar year. The auditor's report shall be presented at the Annual Meeting of the Society by the Chairman of the Finance Committee, and published in the Society Journal.

To be amended to read—Art. B-XI Sect. 6—After December thirty-first, and before the Annual Meeting of the Society in January, the accounts of the Society shall be audited by a certified public accountant, selected by the Council. The auditor's report shall be presented at the Annual Meeting of the Society by the Chairman of the Finance Committee, and published in the Society Journal.

On motion of Professor Larson, seconded by Mr. Cassell, the vote was unanimous in favor of the changes.

President Haynes called upon W. E. Stark, chairman of the Resolutions Committee, for his report which was as follows:

Whereas, the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in Annual Meeting assembled in the City of New York for the period of February 5-9, 1934, inclusive, is about to bring its sessions to a close, and

Whereas, it is altogether fitting and proper as well as a distinct pleasure to remember those agencies, which have so materially contributed to the benefit and pleasure derived from that meeting, therefore

Be it resolved, that we extend to the press of the City of New York and to the technical and trade press, our appreciation of the publicity extended to the Society in bringing its work to the attention of the public, and

Be it further resolved, that we accord to Mr. Paul Whiteman an expression of our appreciation of his personal appearance with his orchestra on the occasion of our President's Reception, and

Be it further resolved, that we wish to convey to the management of the Hotel Biltmore our thanks for the courteous attention rendered, particularly in view of the many difficulties encountered at the time, and

Be it further resolved, that we take pleasure in congratulating Mr. Charles Roth and his associates on the success attending their management of the Third International Heating and Ventilating Exposition, which was held coincidentally with our Annual Meeting, and

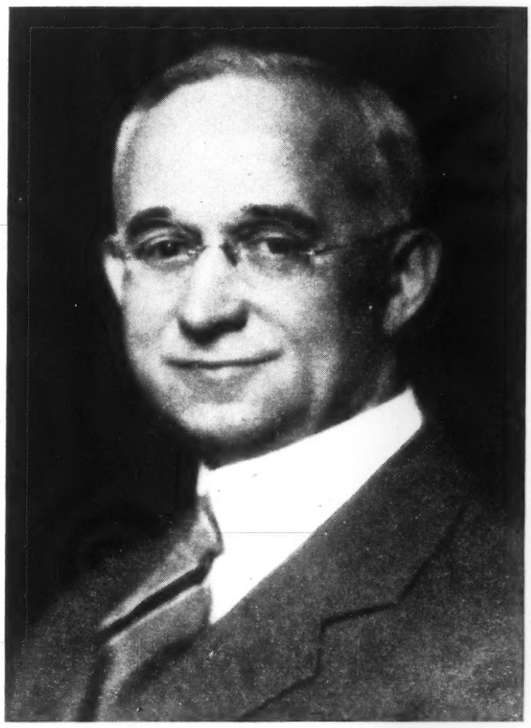
Be it further resolved, that we assure Mr. E. P. H. James, the principal speaker at our Annual Banuet, of our appreciation of his entertaining discourse on that occasion and that we convey to the management of Radio City our thanks for the privilege extended our members and guests to inspect the many interesting mechanical and cultural features of that institution, and

Be it further resolved, that copies of these resolutions be sent to the New York Chapter, to the newspapers and trade press, to the management of Radio City, to Mr. Paul Whiteman, to the management of the Hotel Biltmore, to Mr. Charles Roth and to Mr. E. P. H. James.

The motion to adopt the resolutions offered was made, seconded and unanimously carried.

There being no further business, the motion to adjourn was offered by D. S. Boyden, seconded by Thornton Lewis, and carried.

Officers Elected in 1934

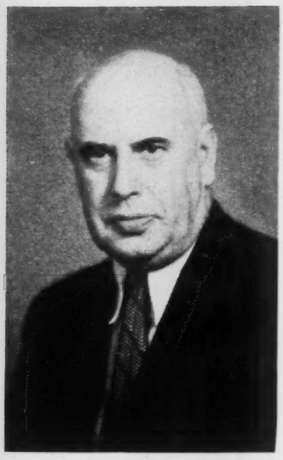


C. V. HAYNES
Philadelphia, Pa.
President

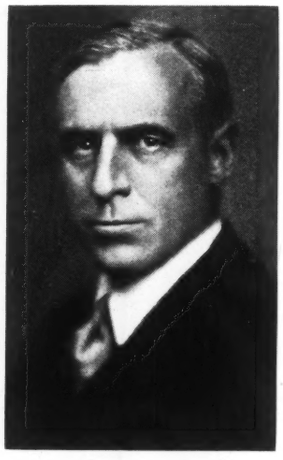
JOHN HOWATT
Chicago, Ill.
First Vice-President

G. L. LARSON
Madison, Wis.
Second Vice-President

D. S. BOYDEN
Boston, Mass.
Treasurer



M. C. Beman
Buffalo, N. Y.
For Three-Year Term



E. H. Gurney
Toronto, Ont.
For Three-Year Term

O. W. Ott
Los Angeles, Calif.
For Three-Year Term

Council Members Who Take Office in 1934

W. A. Russell
Kansas City, Mo.
For Three-Year Term

Albert Buenger
St. Paul, Minn.
For One-Year Term

The Third Heating and Ventilating Exposition

A. S. H. V. E. Officers and Council at the Opening of the Third International Heating and Ventilating Exposition

Seated (left to right): C. V. Haynes, W. T. Jones, John Howatt. Standing (left to right): Charles F. Roth, exposition manager, John Cassell, Roswell Farnham, W. H. Driscoll, R. H. Carpenter, F. C. McIntosh, E. K. Campbell, G. L. Larson, E. H. Gurney, D. S. Boyden, J. F. McIntire and F. E. Giesecke.

A REMARKABLE attendance of 54,000 persons was recorded during the five days of the Third International Heating and Ventilating Exposition held in Grand Central Palace, New York, February 5-9, a period that was also notable for low temperatures and an all-time sub-zero mark of 14.3 for New York City. There was evidence of an intense interest and a definite demand for heating, ventilating and air conditioning equipment on the part of those who were in attendance. The business outlook is most encouraging according to the majority of exhibitors.

Styles in heating, ventilating and air conditioning apparatus change and the most modern ideas of manufacturers indicated that great progress had been made since the first exposition in 1930. A new group of models in warm-air furnaces, steam and hot water boilers, oil furnaces, humidifying and conditioning units, automatic controls, instruments, grilles, fans, fittings, radiators and other accessories brought home to the visitor that automatic heating was not merely an expression, but was an accomplished fact and that any indoor weather condition that might be desired could be achieved.

Booth 56 was the center of A. S. H. V. E. activities and visitors to the Show were able to visualize the extent of the Society's research program at the Laboratory in Pittsburgh and in the cooperating institutions. Demonstrations of the Nicholls' heat meter for heat transmission investigations and the pyrheliometer used in solar radiation studies attracted special attention. A series of wall panels depicted work of cooperating institutions and various Laboratory instruments were appropriately displayed.

Information on the Society and its activities was furnished to those who were interested and THE GUIDE 1934, which made its first appearance at the Exposition, received much favorable comment.

Some indication of the need for air conditioning was given in two small but important exhibits, one by the Health Department of the City of New York and the other by the New York Meteorological Observatory. The former included some biological specimens showing dust particles imbedded in kidneys; and lungs blackened by suspended matter in inhaled air. A chart showed that 4,877 complaints against smoke and cinders were investigated during the past year. The other exhibit showed the extent of the impurities in the air and their variation throughout the year.

Air conditioning equipment on exhibition varied from large industrial systems to the smaller units used for residences. The most numerous items in the air conditioning group were the machines for heating, humidifying and cooling rooms, stores and offices. There were humidifiers, filters, blowers, instruments and control devices in wide variety showing the extensive variety of equipment available for maintaining comfort in occupied spaces. The devices for cooling were many and varied and ranged from portable units and ice containers to the more elaborate mechanical refrigerating devices.

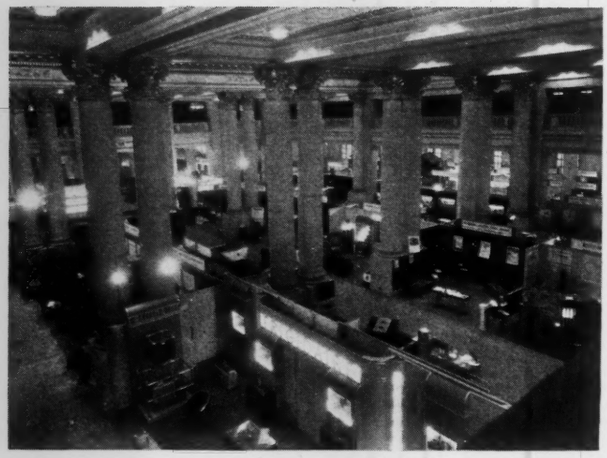
There were furnaces and boilers for coal, oil and gas fuel, also oil burners in profusion, for residential and industrial use, combined boiler and burner units and many types of automatic coal stokers. The cleanliness of gas fuel for house heating was the purpose of a cooperative exhibit and among the firms showing gas fired equipment there were boilers, furnaces, radiant heaters, unit heaters and water heaters.

Among the displays of room heating units, concealed and recessed types of radiation predominated and the finned styles were about equally divided between cast and sheet metal types.

Numerous radiator valves and specialties of grilles, louvers, registers and dampers were to be seen. Temperature measuring and recording instruments ranged from the simplest form of thermometer to telemetering equipment, which will record conditions hundreds of miles distant. Many types of thermostats and humidistats were in evidence and a variety of gages were on display. Both electrically operated and mechanically operated control devices were featured in the many exhibits of this kind of equipment and innumerable applications were listed.

Motors, pumps, fittings and many auxiliary devices were featured among the displays. Insulation for building constructions, as well as for piping of various kinds could be seen. Metallic insulation attracted considerable attention and an asbestos jacket for tanks which could be strapped in place was a new item displayed.

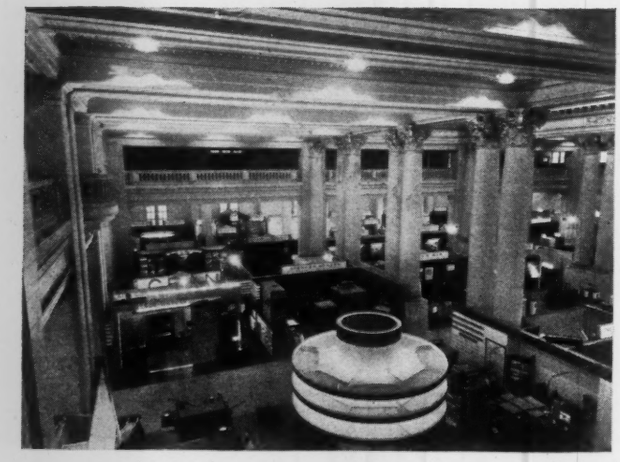
The main floor of Grand Central Palace was crammed full of the most modern equipment available for those interested in heating, ventilating, air conditioning and piping and the exhibitors found that a buying group was in attendance which indicates a most encouraging outlook for the future of the industry.



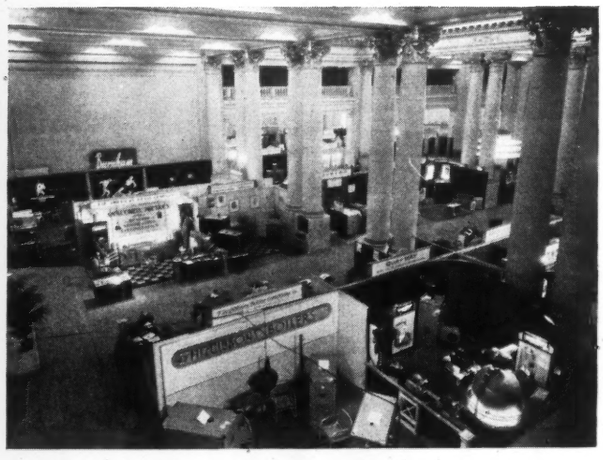
Some of the exhibits at the third heating and ventilating show

Some of the heating and ventilating exhibits in Grand Central Palace

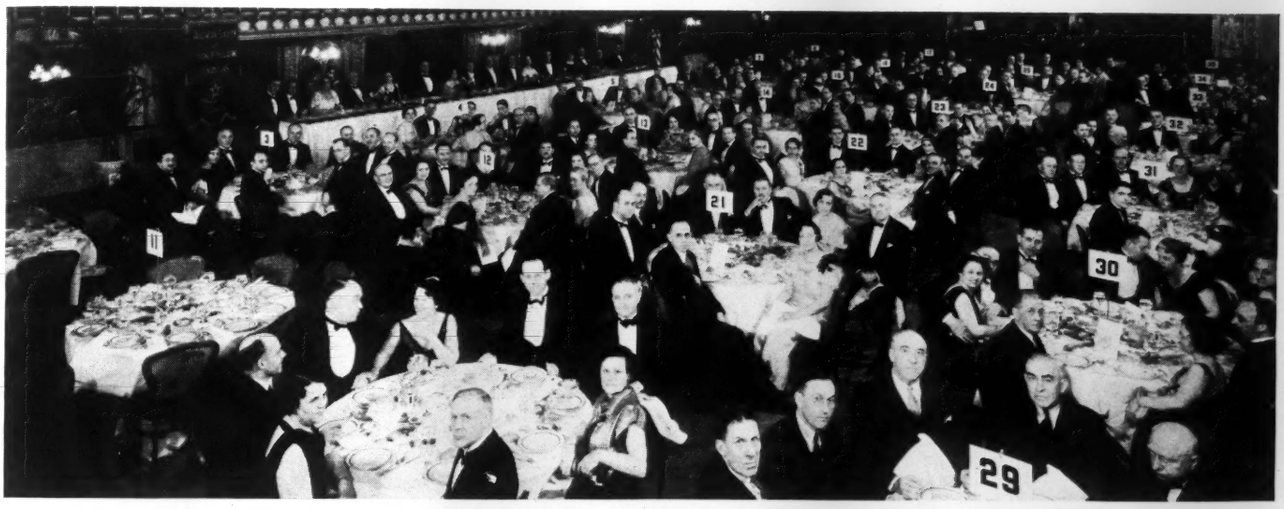
Looking from the balcony, the A. S. H. V. E. exhibit in the foreground



Thousands attended the New York Heating and Ventilating Exposition



General view of the Heating and Ventilating Exposition



The 40th Annual Banquet of the A. S. H. V. E., Hotel Biltmore, New York, Feb. 7, 1934

Fun in Little Old New York

A FINE program of social events was arranged by the New York Chapter Committee, directed by Arthur Ritter and that their efforts were appreciated is evident from the comments of the members at the close of the meeting. Everyone had a wonderful time and decided that the 40th Annual Meeting was a fitting celebration of the Society's four decades of service which began in New York in 1895.

Registration began at the Hotel Biltmore at 9:00 a. m. on Monday, February 5, and the Reception Committee, headed by W. W. Timmis was ready to welcome the visitors to New York. Each day members of the Committee were present to assist the members and guests.

At 1:00 p. m. on Monday the Officers of the Society participated in the formal opening of the Third International Heating and Ventilating Exposition at Grand Central Palace.

At 7:00 p. m. in the Transportation Club, the past presidents held their Annual Dinner with John F. Hale, the senior past president, presiding and the following seated at the table—Messrs. Homer Addams, W. H. Carrier, W. H. Driscoll, H. P. Gant, Thornton Lewis, J. I. Lyle and A. C. Willard. Messages of regret from Messrs. Anderson, Bolton, Hoffman, Jellett, Kimball, Lewis and Still were read, and wires were dispatched to Dean Anderson and Mr. Jellett, whose illness prevented them from being present.

At 10:00 p. m. on Monday evening the President's Reception was held and this was followed by an informal dance and a midnight supper in the Casino Bleu of Hotel Biltmore. Paul Whiteman and his orchestra furnished the music and gave a very entertaining program of musical and vocal numbers. The solos by Ramona, Peggy Healy and Jack Fulton who are well known to radio audiences were greatly enjoyed. With 200 present, a delightful supper was served and dancing was enjoyed until the closing hour. This successful affair was in charge of Alfred Engle, assisted by Messrs. Campbell, Fiedler and Quirk.

On Tuesday afternoon the visiting ladies met for bridge and tea at the Biltmore and those who played were Mrs. F. W. Hvoslef, Mrs. W. A. Russell, Mrs. W. W. Timmis, Mrs. E. K. Campbell, Mrs. R. R. Seeber, Mrs. N. D. Adams, Mrs. A. C. Willard, Mrs. J. C. Matchett, Mrs. J. G. Shodron, Mrs. L. M. Sellers, Mrs. W. T. Jones, Mrs. L. C. Soule, Mrs. A. C. Buensod, Mrs. R. T. Jones, Mrs. J. I. Lyle, Mrs W. H. Driscoll, Mrs. P. D. Close, Mrs. C. W. Stewart, Mrs. M. C. Gillett, Mrs. C. H. Quirk, Mrs. Thomas Chester, Mrs. H. W. Fiedler and Mrs. R. Farnham. Mr. C. S. Hoffman, assisted by Mrs. Hoffman and Mrs. Clyde R. Place were the host and hostesses on this occasion.

The big social event of the meeting was the annual banquet held in the Cascade Ballroom of the Hotel Biltmore on Wednesday evening, February 7. W. H. Driscoll acted as toastmaster and during dinner two solos were given by Fernando Villa. Following dinner, Mr. Driscoll called upon Thornton Lewis to present the retiring President, W. T. Jones, with the past president's medal. Mr. Jones responded briefly and expressed his appreciation for the handsome emblem.

The speaker of the evening was E. P. H. James, Sales Promotion Manager of the National Broadcasting Co., who gave a very entertaining account of the difficulties involved in broadcasting short wave programs and recounted some of the humorous experiences with stars and the interesting contents of fan mail.

Mr. Driscoll read a message from Dean Anderson who was unable to be present because of a serious operation and Mr. Lewis was delegated to write a letter of greeting from those assembled and express their hope for his prompt and complete recovery. Percy Seward, New York, was introduced by the Toastmaster as the only man present who had attended the organization meeting of the Society in New York 40 years previously.

The newly elected President, C. V. Haynes, Philadelphia, was introduced to the audience and responded very briefly.

The floor was then cleared for dancing and the Meyer Davis Orchestra which had played several selections during dinner, gave a program of dance music that was enjoyed by everyone until 12:30 a. m.

On Thursday morning the technical session was omitted so that the members could visit Radio City and inspect the mechanical equipment in the N. B. C. and British Buildings. Over 200 assembled at 9:30 a. m. at Radio City and with guides to show the way, the members saw the various mechanical installations, control rooms and broadcasting studios. This inspection tour had been arranged by W. S. Keplinger. On Thursday afternoon the ladies attended the theatre party at Radio City Music Hall and enjoyed the program of pictures and a stage show.

The program had been so arranged that leisure hours permitted attendance at the Heating and Ventilating Exposition at Grand Central Palace, shopping tours for the ladies, dinner and theatre parties and any other function that visitors might desire.

COMMITTEE ON ARRANGEMENTS
Arthur Ritter, *General Chairman*

FINANCE
F. E. W. Beebe, *Chairman*
J. B. Hashagen — W. M. Heebner

BANQUET
H. B. Hedges, *Chairman*
Russell Donnelly — A. J. Offner
Walter Heibel — E. J. Ritchie

RECEPTION
W. W. Timmis, *Chairman*
E. A. Bennett — G. F. Olsen
F. B. Campbell — W. F. Rainger
M. E. Durkee — Louis Hament
H. B. Eells — H. T. Richardson
Margaret Ingels — E. J. Ritchie
H. G. Meinke — E. S. White

ENTERTAINMENT
Alfred Engle, *Chairman*
F. B. Campbell
H. W. Fiedler — C. H. Quirk

LADIES
C. S. Hoffman, *Chairman*
C. R. Place
Mrs. C. S. Hoffman — Mrs. C. R. Place

RADIO CITY INSPECTION TRIP
W. L. Keplinger, *Chairman*
C. S. Hoffman, *Vice-Chairman*

PUBLICITY
R. B. Purdy, *Chairman*
Clifford Strock

Cleveland

January 11, 1934. The January meeting, held at Case School of Applied Science, was preceded by an inspection of the Mechanical Engineering Laboratory where the equipment used for routine testing and special investigations in the field of heating and ventilating was in operation. The regular meeting was called to order by Pres. F. A. Kitchen at 8:15 p. m., with 52 members and guests present.

In the absence of the chairmen of the Membership Committees, W. E. Stark nominated Donald Thompson for membership in the Cleveland Chapter and the nomination was seconded and carried. C. A. Wheeler nominated R. M. Spencer for membership in the Chapter to become effective at the time of his election to the Society. This was also seconded and carried.

The secretary, M. B. Wright, stated that a communication had been received from Secy. A. V. Hutchinson and discussed briefly the items mentioned. Following this he read a letter received from a firm desiring sales representation in the Cleveland territory.

E. J. Vermere moved that the Chapter show their appreciation of the time and trouble taken by F. C. Houghten to speak before the Chapter in November by defraying the speaker's transportation expenses. The motion was seconded and carried.

H. M. Nobis called attention to the Cleveland slum elimination project contemplated by the P. W. A. and moved that the Chapter secretary communicate with officials at Washington, who are supervising this work, and offer the cooperation of the Chapter in making a survey of possible types of heating systems. After considerable discussion the motion was withdrawn and a substitute motion made to the effect that the president of the Chapter appoint a committee to cooperate with the consulting engineers in recommending the most suitable heating and ventilating equipment to be used in the public works program, providing this arrangement is agreeable to the consulting engineers. The motion was seconded and, after further discussion, was carried.

Following the regular business, Secretary Wright was asked to take charge of the meeting and introduce the guest speakers.

Prof. G. L. Tuve gave an interesting résumé of Research and Experimental Work in Heating and Air Conditioning at Case School. After outlining the divisions of the work conducted, such as prescribed classroom courses, laboratory courses, research projects, and commercial work, Professor Tuve described in detail the cooperative project with the A. S. H. V. E. on heat transfer in finned convectors under forced air circulation. Pictures were shown of the test equipment and results obtained using different types of air disturbers. He also discussed the results obtained during another project on heat transfer and distribution with hot water convectors.

Following Professor Tuve's talk, Prof. J. R. Martin spoke on the Measurement and Elimination of Noise in Ventilating Equipment. Professor Martin explained the difference between noise and sound and discussed the difficulties encountered in sound measurement. He made clear the meaning of the term described and by means of a chart showing equivalent loudness, presented values in decibels for various types of noises. After describing the instruments used in noise measurement, he spoke briefly on methods of noise elimination.

Several interesting points were brought out during the general discussion of these two presentations.

A rising vote of thanks was extended to the speakers and the meeting adjourned at 10:45 p. m.

December 14, 1933. The December meeting, held at the Cleveland Club, was preceded by a dinner, which was enjoyed by 21 members and guests, and when Pres. F. A. Kitchen called the meeting to order an attendance of 90 was recorded.

H. M. Nobis, treasurer, reported a balance of $22.00 in the current account and requested members to pay dues promptly.

Secy. M. B. Wright announced that the next meeting would be held at Case School of Applied Science with Prof. G. L. Tuve and Prof. J. R. Martin as speakers. The date was tentatively set for January 11.

President Kitchen called for nominations of new members and C. A. Wheeler, representing the Blue Team, proposed Professor Tuve for chapter membership and also nominated E. F. Steffen and H. F. Curtis contingent upon their election to membership in the Society. These nominations were seconded and carried. W. E. Stark, representing the Red Team, proposed the name of J. S. O'Gorman for membership to become effective at the time of his election to the Society. This nomination was seconded and carried. Secretary Wright was instructed to notify these gentlemen of the action taken.

Mr. Stark was asked to make an announcement regarding the Annual Meeting and Exposition to be held in New York in February. He mentioned the technical papers that he considered to be of particular interest and urged all members to attend.

Following the regular business of the meeting, M. F. Rather was called upon to introduce the guest speaker, J. H. Walker, of Detroit.

The subject of Mr. Walker's talk was Experiences with Summer Cooling in Detroit and, with the aid of slides, he described the experiments conducted during the summers of 1932 and 1933 in an 8-room residence. Ice and city water were used as cooling mediums and the air was circulated through the warm air heating system by means of a fan. The estimated cost of the installation was $400.

During 1932 the system was operated with unrestricted cooling and the total operating cost amounted to $38. In 1933 a fan was installed in the attic for the purpose of drawing cool night air into the second floor rooms, the use of the cooling system was restricted and the operating costs were reduced to $28.

It was found that the circulation of air at the rate of seven air changes per hour was not of any great benefit. No tests were made using a compression system of refrigeration, but it is planned to do this in the future. The use of an attic fan was studied and results indicated that this method of cooling has possibilities, the operating costs being only $10. It was pointed out that the systems used for cooling this house were not package products, but required a certain amount of engineering. Mr. Walker's talk inspired considerable discussion and a great many questions were answered by the speaker.

A rising vote of thanks was extended to Mr. Walker and the meeting adjourned at 9:45 p. m.

Illinois

The Illinois Chapter, A. S. H. V. E., held a joint meeting with the Chicago Section *American Society of Refrigerating Engineers* at the Hotel Sherman on February 12, 1934 and members of the *American Society of Bakery Engineers* were special guests on that occasion.

Dinner was served at 6:30 p. m. in the Old Town Room. Pres. Charles DeLand called the meeting to order at 7:30 p. m. with 262 present.

The reading of the minutes of the January meeting was dispensed with by vote. The Secretary was called upon to give a brief report of the Fortieth Annual Meeting of the A. S. H. V. E. held at the Hotel Biltmore, New York City, February 5th to 9th. He reported on the election of John Howatt to the office of First Vice President of the National organization. Mr. Howatt then gave a short talk on his impression of the annual meeting.

President DeLand introduced the officers of the three organizations present.

E. V. Lippe, was then called upon to introduce Irving R. Brooke, his confrere, who spoke on C. W. A. Project No. 1504, covering Smoke Inspection and Abatement.

Mr. Brooke outlined this project which originally was planned to employ 1,800 men to cover metropolitan Chicago. After listening to Mr. Brooke's description of the work already accomplished, no doubt, every one present, irrespective of his previous views on the C. W. A., at least reserved his opinion of this one Federal project.

The meeting was then turned over to Professor E. S. Libby, President of the Illinois Section *A. S. R. E.*, who introduced the speaker of the evening, W. W. Reece, chief engineer of the W. E. Long Co. Mr. Reece's subject was "Air Conditioning in Bakeries" and his talk was accompanied by two reels of motion pictures and a number of slides, which illustrated a complete air conditioned bakery in Southern California.

The bread-baking process was outlined, from the storage of raw material to the delivery of the finished product, sliced and wrapped, to the delivery trucks. While careful control of temperature and humidity is important in all parts of the operation, special attention is given to these conditions in the raw material storage room, the fermentation department, the proofing room, and the cooling, slicing and wrapping division of the plant.

Mr. Reece supplied definite recommendations covering the temperatures and relative humidities required in each department, and emphasized the importance, especially in the fermentation room, of uniform air distribution, good duct design, and sufficient refrigeration, together with the necessity of an adequate supply of pure water at 33 to 35 F for the mixing room. He described some of the serious defects in the finished product, resulting from the lack of proper air conditioning.

The baking industry apparently recognizes the urgent need of air conditioning equipment, preferably simple and sturdy in construction and relatively low in first cost, in order to permit sound baking practice, good working conditions, and better management.

Mr. Reece made the statement that proper control of temperature and humidity will pay a return of from thirty to forty per cent on the investment in the apparatus.

Professor Libby conducted the meeting during an interesting discussion which followed Mr. Reece's talk. The wonderful attendance at this joint meeting should encourage the committee to plan others of similar character in the future, says the report of Secy. J. J. Hayes.

January 8, 1934. The meeting was held in the Crystal Ballroom of the Hotel Windermere East. Ladies were invited to this gathering and dinner was served at 7:30 p. m. to 137 members and guests. It was preceded by an inspection visit to the Museum of Science and Industry, founded by Julius Rosenwald, and located on the site of the old World's Fair in Jackson Park. This meeting proved to be one of the most delightful in recent years. While the museum is not completed, many exhibits are in place and a private showing with guides was granted to the members. The inspection included a trip through a model coal mine in operation, a fine exhibit of elevating and conveying machinery and mine ventilating equipment. Other exhibits covered the following subjects: Sound and Music, Chemistry, Welding, Strength of Materials, Die-Making, Electricity and Diving.

After dinner, Pres. C. W. DeLand called the meeting to order at 8:45 p. m.

A motion was made by A. B. Martin and seconded by H. G. Thomas to invite the Society to hold its Annual Meeting in 1936 in Chicago. This motion was passed by vote.

President DeLand called the members' attention to the 40th Annual Meeting of the Society in New York City, February 5-9, and urged each member to attend.

President DeLand then introduced J. R. Van Pelt, assistant director of the Museum of Science and Industry, who briefly outlined the plans for the future of the museum.

The meeting was then turned over to O. T. Kreusser, director, who devoted the greater part of his talk to the purpose and aims of the Museum, and told of the desire to portray the history of man's development of machines, and to gather young men together and inspire them with exhibits which leave a lasting impression. Mr. Kreusser made the statement that one good truthful exhibit free from propaganda, an exhibit with appeal, is worth acres of glass cases. He is working for mental youthfulness and mentioned the manufacture of automobiles as an illustration of one of our youngest and most progressive industries.

Mr. Kreusser ended his interesting talk with an urgent invitation to each of the members and guests to pay many future visits to the Museum. According to Secy. J. J. Hayes, the enthusiastic vote of thanks which followed indicated that the invitation would be accepted.

Kansas City

December 11, 1933. The Kansas City Chapter met at the Newbern Hotel and the principal speaker of the evening was L. B. Miller, of Minneapolis, Minn. Mr. Miller demonstrated and explained in a very interesting manner the newly perfected effective temperature control equipment.

E. K. Campbell gave a report of the Council meeting held in Chicago. Mr. Campbell also read a letter from D. D. Zink, Vice-President of the Chapter, describing vividly and entertainingly his duties and work as director of a Civilian Conservation Corps Camp in Oregon.

The meeting was very well attended not only by members, but also by a number of guests.

Michigan

January 22, 1934. Approximately 80 members and guests attended the dinner given by The Detroit Edison Co., who were hosts to the Michigan Chapter. After dinner, three reels of films, showing Michigan wild life and animals, were screened.

The speaker of the evening, H. A. Snow, addressed the meeting on the subject of Public Utility Dollars. Mr. Snow related the history of the formation of The Detroit Edison Co. and covered the progress of development from the first Delray plant of five 3000 kw steam turbines to the present plant capacity of nearly 750,000 kw. At the conclusion of his talk, a number of questions were asked by Messrs. Chester, Bishop, Zork, Rowe, Kilner and Brown.

Members and guests were then entertained by some excellent singers and a very clever juggler before Mr. Winans turned the meeting over to Pres. H. E. Paetz for the business of the evening.

President Paetz expressed the sincere appreciation of the

Chapter for the most enjoyable dinner and evening provided for them.

The chairman of the Program Committee, W. G. Boales, gave a very interesting announcement on the next meeting, to be a dinner dance at the Wardell Hotel on February 12.

J. F. McIntire, member of the Council, was called upon and strongly urged everyone to attend the Annual Meeting and Exposition in New York, February 5-9.

The meeting adjourned at the usual hour of 10:00 p. m.

December 11, 1933. The December meeting with 65 members and guests present was held at the Wardell Hotel. After a fine dinner, Pres. H. E. Paetz expressed regret that the secretary, Tom Brown, could not be present because of the death of his mother.

Treas. R. K. Milward reported a balance of $343.13, which included ten per cent of the amount impounded in a closed bank.

Two new applications which had been accepted were read for M. C. Terry and W. O. Smith.

Announcement was made of the January 22 meeting, to be held at the Detroit Edison auditorium. W. G. Boales urged all to attend the Society's Annual Meeting and Exposition in New York, February 5-9.

President Paetz introduced S. R. Lewis, Chicago, who was the speaker of the evening.

Mr. Lewis gave a paper on Air Conditioning, in which he illustrated some of the errors of the early installations. He expressed the opinion that the art of air conditioning was best left in the hands of designing engineers. The speaker also explained some of the problems of temperature control and air distribution, giving considerable attention to schoolroom ventilation.

Mr. Lewis, who is chairman of the Society's Committee on Nomenclature, used many new terms, a number of which he explained in detail.

The meeting was very much interested in Mr. Lewis' paper, as was shown by the comments which followed.

Dr. Lee Simpson reminded the meeting of the health benefits to be obtained from air conditioning and the following men took part in the discussion: N. B. Hubbard, E. L. Hogan, L. L. Smith, Thomas Chester, A. P. Darlington and W. A. Rowe.

Several requests were made to have Mr Lewis' paper printed and distributed. After the discussion President Paetz called for a rising vote of thanks to the speaker.

Ontario

February 6, 1934. The regular meeting of the Ontario Chapter was held at the Royal York Hotel, when, following a delightful dinner served at 6:00 p. m., Pres. W. P. Boddington introduced the evening's speaker, Mr. Storrie, of Gore, Nasmith and Storrie, consulting engineers of Toronto. Mr. Storrie spoke on Engineering in Relation to Public Health.

Following a very instructive talk on water supply systems for various cities throughout Canada and on sewage disposal plants, Mr. Storrie showed slides of prominent engineering projects which have been completed through the whole of Canada.

Pacific Northwest

January 29, 1934. A joint meeting with the *A. S. M. E.* was held at the Engineers Club in the Arctic Building, with 35 members from both organizations present for dinner and the program that followed.

Fairman Lee, chairman of the Northwest Section of the *A. S. M. E.*, called the meeting to order and, due to the fact that the meeting was held jointly, no official business was transacted.

A very interesting lecture on the different types of equipment and methods used for complete air conditioning was given by Harry Brod of Portland, Ore., who illustrated his talk with slides.

E. L. Weber, consulting engineer, then gave a discussion of the practical applications of air conditioning and its bearing on comfort and health. The questions and answers that followed brought out many features of the industry which will require considerable research to arrive at a satisfactory solution for practical installations.

December 19, 1933. Twenty-four members and guests were present at this meeting and the Membership Committee reported 8 new members with the prospect of at least one more application before the first of the year.

The chairman of the Program Committee stated that the next meeting would be devoted to short talks from all of the new members.

Pres. P. M. O'Connell announced that the code pertaining to professional engineers had not yet been signed. He appointed Kenneth MacLeod, Howard Cook and C. W. May as members of the Technical Committee.

The meeting was then turned over to A. L. Pollard, chairman of the Program Committee, who introduced Prof. S. K. Kirsten of the University of Washington.

Professor Kirsten gave a talk on the advancement of neon lighting, which was very interesting to mechanical engineers.

Mr. Pollard, chief engineer of the Puget Sound Power and Light Co., extended an invitation to all present to inspect an installation of a new 600 hp electric high pressure boiler in a large steam plant. The purpose of this boiler is to use excess current generated by hydro-electric and it has been operating constantly for one week at practically 98 per cent efficiency. This performance enables the operators to take off a steam boiler of the same capacity from the line. The voltage across terminals is 4600 volts.

Philadelphia

January 16, 1934. The annual meeting of the Philadelphia Chapter was held at Colonial Recreation Center. Following dinner, Pres. M. F. Blankin asked for the reading of the minutes of the previous meeting, which were approved as read. Treas. J. H. Hucker presented his annual report on the financial condition of the Chapter, which was also approved.

The Auditing Committee, consisting of H. H. Erickson, chairman, L. P. Hynes and R. S. Arnold, stated that they had audited the books of the Chapter and found them correct. A copy of their report was ordered filed in the records.

W. F. Smith, chairman of the Meetings Committee, presented President Blankin with a beautiful automobile robe as a token of appreciation for the unusually good work he had done as president during 1933. In accepting this gift of appreciation, President Blankin sincerely thanked his officers and Board of Governors for their cooperation during his term of office.

President Blankin presented the nominations prepared by the Nominating Committee for Chapter officers and Board of Governors to serve during 1934:

President—W. P. Culbert.
Vice-President—J. H. Hucker.
Secretary—W. R. Eichberg.
Treasurer—W. F. Smith.
Board of Governors—M. F. Blankin, A. C. Caldwell and Alexander McClintock, Jr.

There being no other nominations, a motion was made and passed authorizing the secretary to cast a unanimous ballot for the slate presented by the Nominating Committee, which he did, and President Blankin declared the nominees duly elected.

The retiring president called Mr. Culbert to the chair and presented him to the membership as the President for 1934 and turned the gavel over to him.

President Culbert made a short address and presented the new officers and Board of Governors.

The secretary, W. R. Eichberg, addressed the meeting in connection with the Society's Annual Meeting in New York, February 5-9, and the Heating and Ventilating Exposition.

The treasurer, Mr. Smith, made a plea for the payment of dues as promptly as possible.

Jimmy Dykes, third baseman for the Chicago White Sox and former member of the Athletics, made a short and interesting address on amusing incidents he had experienced during his years in baseball.

The meeting was then turned over to Mr. Smith, who had arranged for bowling, refreshments and cards for the remainder of the evening.

A delightful time was had by everyone of the hundred members and guests present and it was their unanimous opinion that this was one of the most successful and interesting meetings ever held by the Chapter.

December 14, 1933. Following dinner, 41 members and guests of the Philadelphia Chapter assembled in the auditorium of the Engineers Club, where the meeting was called to order by Pres. M. F. Blankin.

The minutes of the previous meeting were approved as read and the monthly report of the treasurer, J. H. Hucker, was received.

W. F. Smith, chairman of the Meetings Committee, asked Benjamin Adams to present the speaker of the evening, F. D. Berkeley. Mr. Berkeley gave a very interesting paper on Steam Jet Refrigeration and ably answered many questions which were asked during the discussion.

President Blankin assured Mr. Berkeley that the Chapter was deeply grateful for his visit to Philadelphia to give so much interesting information.

H. G. Black reported that over three-fourths of the Chapter's quota for the Technical Committee Relief had been subscribed with practically all subscriptions paid.

The program for the Annual Meeting of the Society to be held in New York, February 5 to 9, was outlined by President Blankin, who requested members to begin making their plans to attend and drew attention to the Heating and Ventilating Exposition.

Mr. Smith announced that the Chapter's annual meeting would be a night of indoor sports to be held at Jimmy Dykes Bowling Emporium on January 16.

Pittsburgh

December 11, 1933. The annual meeting of the Pittsburgh Chapter was held in the offices of F. C. McIntosh with 25 members in attendance. A delicious home-cooked dinner, served by the members, preceded the meeting, which Pres. G. S. McEllroy called to order at 8:00 p. m.

President McEllroy stated that the first new business was the election of officers for 1934. He presented the nominations made at the November meeting and called for additional names from the floor. It was moved and seconded that nominations be closed and the secretary, J. L. Blackshaw, was instructed to cast a unanimous ballot.

The officers thus elected for 1934 were:

President—P. A. Edwards.

Vice-President—L. B. Pittock.

Secretary—J. L. Blackshaw.

Treasurer—H. A. Beighel.

Board of Governors—G. S. McEllroy, F. H. Hecht, R. J. J. Tennant.

In a speech of acceptance, Mr. Edwards stated that despite conditions, he looked for a successful year for the Pittsburgh Chapter.

F. C. Houghten gave some important data received from headquarters' office concerning 1934 dues; he discussed the Society's Annual Meeting and the Heating and Ventilating Exposition; and he asked that members mail in their address cards promptly so that proper listings could be made in the Roll of Membership.

Secretary Blackshaw read a resumé of a conference of representatives of engineering societies held in New York on November 24 to consider NRA Codes for the profession.

Mr. McEllroy appealed to members to pay their delinquent dues and asked prompt payment of those for 1934.

In place of the usual formal address, a round-table discussion was held at which several good ones were told. Secretary Blackshaw reports that what brought down the house was Mr. Harper's story about the plant store.

Moving pictures shown of the technical operation of telephones and telephone systems were well received.

St. Louis

February 5, 1934. A meeting at the David Ranken, Jr., School of Mechanical Trades, preceded by dinner in the School Cafeteria, was attended by 23 members and guests. Pres. Paul Sodemann welcomed the members of the *A. S. R. E.* who were guests of the Chapter on this occasion.

The minutes of the January meeting were read and approved and the Secretary, A. L. Walters, reporting for the Treasurer, who was absent, showed a balance on hand of $334.78.

D. J. Fagan, chairman of the Membership Committee, reported that he had several likely prospective members whom he hoped to be able to present for membership before the next meeting.

President Sodemann paid tribute to Henry Baetz, a member of the Society and formerly a member of the Chapter, who died recently.

The meeting adjourned, after which members attended the Open Forum on Air Conditioning in the School Gymnasium at 8:15, when nearly 500 were in attendance at this meeting. The series of meetings is sponsored, among others, by the St. Louis Chapter. C. E. Parmalee was forum leader for the evening and read and discussed a very interesting paper on Cooling and Dehumidification.

January 15, 1934. The meeting was called to order in the David Ranken School of Mechanical Trades by Pres. Paul Sodemann with 25 members and guests present.

J. W. Cooper, chairman of the Program Committee, outlined the programs for the February and March meetings, to be held at the school coincident with the date of meetings of the Air Conditioning Forum.

Mr. Cooper suggested a joint meeting for March with the *A. S. R. E.* and Mr. Kipp, secretary, indicated that this arrangement met with the approval of his organization. It was moved and seconded that the secretary invite the St. Louis Section of the *A. S. R. E.* to meet with the St. Louis Chapter of the A. S. H. V. E. on March 5. The motion was carried.

A communication from Secy. A. V. Hutchinson in regard to the New York meeting was read and President Sodemann urged members to attend.

C. A. Pickett and G. B. Rodenheiser spoke in regard to the demand for speakers at clubs on Air Conditioning. President Sodemann suggested that these requests be referred to the Educational Committee and that the Chapter would be glad to furnish such speakers. Mention was made of the care with which all papers presented in the Forum had been and would be edited to eliminate reference to any particular company or its products.

The report of the Auditing Committee was read by Mr. Cooper, chairman.

President Sodemann expressed the appreciation of the Chapter to the School and Mr. Turner replied, thanking the Chapter for its cooperation in connection with the Air Conditioning Forum and the splendid interest taken in it.

The meeting was adjourned at 7:50 p. m., after which the Chapter attended the first meeting of the Open Forum on Air Conditioning. It is estimated that at least 700 persons were in attendance when E. A. Freund spoke on What Is Air-Conditioning?

December 6, 1933. A dinner in the Tavern of the Kings-Way Hotel preceded the meeting of the St. Louis Chapter, which was called to order by Pres. C. A. Pickett.

L. W. Moon, a member of the Council, read a report from

Secy. A. V. Hutchinson, giving full information regarding the 40th Annual Meeting of the Society to be held in New York in February.

J. W. Cooper moved that Mr. Moon be instructed to invite the A. S. H. V. E. to hold its Annual Meeting in St. Louis in 1935 and this was seconded by Paul Sodemann and carried.

Treas. A. L. Walters reported a balance on hand as of December 6 in the amount of $342.20.

President Pickett presented a very interesting report of the activities of the Chapter during the past year, as follows:

It will interest members of the local chapter to know that with the fiscal year ending with this meeting we have a bank balance of $342.20 with a net gain of $15.00 from December 31, 1932. With a budget of $200.00, only $126.00 was spent during the year.

Applications have been received from 8 new members. This is a net gain of four new members, as four members discontinued their association with the Chapter during the past year.

Total attendance at the various meetings for the year was 310, exclusive of the summer party, making a total of 330 for the year.

The largest meeting was in February, at which time 90 members and guests were present at the David Ranken Trade School, when E. A. Jones, Milwaukee, presented a paper on Domestic Air Conditioning.

The next largest meeting was in October when 65 members and guests were present at the David Ranken Trade School, when F. D. Berkeley, Buffalo, N. Y., presented a paper on Steam Vacuum Refrigeration.

Following his report, President Pickett turned over the chair to Mr. Moon for election of officers.

The Nominating Committee submitted the names of the following candidates for office, who were duly elected:

President—Paul Sodemann.
1st Vice-President—J. W. Cooper.
2nd Vice-President—C. R. Davis.
Treasurer—G. W. F. Myers.
Secretary—A. L. Walters.
Board of Governors—C. A. Pickett, E. B. Evleth, J. M. Foster, E. E. Carlson.

After the annual election of officers, J. W. Cooper, chairman of the Entertainment Committee, took charge of the meeting, which was devoted to a story telling contest with a prize awarded for the best or worst story pertaining to the heating and ventilating industry. Mr. Walters, newly elected secretary, was unanimously awarded the prize for the best story.

Mr. Pickett, the retiring president, turned the meeting over to President Sodemann, and all of the new officers made short speeches.

Mr. Myers moved that the January, February and March meetings be arranged to coincide with the Air Conditioning Forum at David Ranken Trade School and this was seconded by Mr. Pickett and carried.

President Sodemann named Mr. Cooper as chairman of the Auditing Committee with Messrs. Moon and Carlson as members, and announced the appointment of Mr. Pickett as representative on the Society's Nominating Committee and Mr. Myers as alternate.

Western New York

January 8, 1934. This meeting, the first in the new meeting place, the Touraine Hotel, showed a marked improvement in attendance and everyone was favorably impressed with the change.

A motion was made and seconded to have the Dance Committee, consisting of Joseph Davis, chairman, P. S. Hedley and Roswell Farnham, proceed with arrangements for the annual mid-winter dance.

W. E. Voisinet was appointed to look into transportation facilities for the Annual Meeting of the Society in New York and to urge a large delegation from the Chapter.

A motion was made and carried to have the secretary cast a unanimous vote for the following officers, who were thus elected:

President—J. J. Yager.
First Vice-President—W. F. Johnson.
Second Vice-President—W. E. Voisinet.
Secretary—P. S. Hedley.
Treasurer—B. C. Candee.

The retiring president, D. J. Mahoney, then called upon the following past presidents who were present: W. G. Fraser, Roswell Farnham, C. W. Farrar, C. A. Evans, M. C. Beman and Joseph Davis.

Mr. Johnson introduced the speaker of the evening, J. Burnham, of Philadelphia, Pa. Mr. Burnham discussed the topic of copper pipe and fittings in a thorough and able manner. The continued discussion was evidence of the interest aroused in this timely subject.

Mr. Mahoney then made a motion to install the new officers, which, after a lively discussion, was seconded by Mr. Evans and carried.

A rising vote of thanks to the speaker closed a very enjoyable and entertaining meeting.

Wisconsin

January 25, 1934. The January meeting of the Wisconsin Chapter was held in the Mirror Room of the Pfister Hotel, where dinner was served at 6:30 with a very nice attendance.

The meeting was called to order at 8:00 p. m. by Pres. J. S. Jung.

After the routine business had been disposed of, President Jung introduced J. F. Heil, Milwaukee, who gave a paper on Thermal Engineering in Breweries. The presentation covered a complete brewing process, giving special attention to those phases involving heat transfer.

Secy. G. E. Hochstein reports that the meeting adjourned at 10:15 p. m.

December 27, 1933. Approximately 16 members were present for a dinner, which preceded the meeting of the Wisconsin Chapter in the Pfister Hotel.

At 8:00 p. m. Pres. J. S. Jung called the meeting to attention and asked Ernest Szekely to present the speaker, T. A. Novotney, Johnstown, Pa. Mr. Novotney's subject was the Design of Convectors and his talk was a very interesting one, telling of the research and experimental work necessary to develop a concealed radiator.

After the conclusion of the paper, the members spent a short time in discussion.

At this time, E. A. Jones was appointed representative for the Chapter on the Nominating Committee and Ernest Szekely was named as alternate.

Cincinnati

February 13, 1934. Thirty-four members and guests of the Cincinnati Chapter held a meeting at the Engineers' Club and were called to order by their newly elected president, H. N. Kitchell.

R. H. Heilman, Senior Educational Fellow, Mellon Institute of Industrial Research, gave the first address on Heat Conservation from an Engineering Standpoint. Mr. Heilman's talk covered the following phases: heat losses from bare surfaces, copper and iron; theory of heat insulation; commercial types of heat insulation; savings effected by insulation; and economical thickness of insulating materials. The speaker covered the subject very thoroughly and illustrated his remarks with slides.

The second presentation was given by W. L. Steffens, Cincinnati, and covered some very interesting examples of the use and misuse of heat insulating materials. Mr. Steffens spoke of temperature gradients in high temperature insulation, temperature limits of various insulations, and general rules for determining the proper thickness of insulation.

This meeting was reported by E. B. Royer, secretary of the Chapter.

Philadelphia

February 8, 1934. The regular meeting of the Philadelphia Chapter was held at the Engineers Club, when following dinner, Pres. W. P. Culbert called for the reading of the minutes of the previous meeting.

Treas. W. F. Smith gave his report and a motion was made and approved that this be filed with the minutes.

President Culbert gave the list of members appointed to the Meetings, Membership, Attendance, Publicity, Finance and Legislative Committees.

Mr. Smith announced that the March meeting would be held at the Philadelphia Savings Fund Society Building, where dinner would be served, followed by an inspection of the building.

Morris Sheffler introduced the speaker, W. C. Beekley, Hartford, Conn., who presented a paper on Hot Water Generators and the Btu as the Dollar Mark of Savings, which was most interesting and instructive. Following his talk, Mr. Beekley answered the questions of various members.

President Culbert thanked the speaker for his presentation and a rising vote of thanks was given him by the members.

William N. McKenna Dies

In the death of William N. McKenna, on January 25, 1934, the Society lost a Life Member who was highly respected by all with whom he came in contact.

Mr. McKenna was treasurer of the William N. McKenna Co., heating, ventilating and plumbing engineers and contractors, with offices at 79 Chestnut St., Boston, Mass.

Born on November 5, 1859, in Boston, he attended the public schools of the city and began his engineering career as apprentice at Boston and Lynn with Riley and Hill. His drafting and shop experience was obtained with L. A. May and Co. of Lynn and Buerkel and Co. of Boston.

In 1884 he started business under his own name and was responsible for the design and construction of installations in many private residences and public and mercantile buildings throughout New England.

Mr. McKenna became a Member of the American Society of Heating and Ventilating Engineers in 1912 and, upon reaching the age of 70, was granted Life Membership in 1929.

The funeral on January 27 proceeded from his residence at 21 West Cedar St., Beacon Hill, and was followed by a solemn mass of requiem at St. Joseph's Church.

The Officers and Council of the Society have expressed to his son, William N. McKenna, Jr., who survives, their sincere sympathy.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 32 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some members by March 15, 1934, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
Bird, Charles, Treas. and Genl. Mgr., Doermann-Roehrer Co., Cincinnati, O.	G. B. Houliston	C. J. Kiefer
	W. C. Green	E. B. Royer
Brennan, John W., Sales Engr., American Blower Corp., Detroit, Mich.	A. P. Darlington	E. L. Hogan
	H. E. Paetz	G. D. Winans
Campbell, Robert E., Student, Pratt Institute, Brooklyn, N. Y.	J. W. Hunter (*Non-Member*)	R. C. Knowles (*Non-Member*)
	R. B. Dale (*A.S.M.E.*)	H. L. Cameron (*Non-Member*)
Cheeseman, Evans W., Student, Carnegie Inst. of Technology, Pittsburgh, Pa.	T. F. Rockwell	C. E. Wright
	C. M. Humphreys	A. H. McMunn
Denny, Harold R., Mgr., N. Y. Merch. Dept., American Blower Corp., New York, N. Y.	Arthur Ritter	F. R. Still
	E. A. Bennett	D. L. Taze
Fogarty, Orville A., Mgr. and Chief Engr., Canadian Fairbanks-Morse Co., Montreal, Que., Canada.	Thomas McDonald	T. E. McGrail
	F. G. Phipps	G. L. Wiggs
Galloway, James F., Student, Pratt Institute, Brooklyn, N. Y.	J. W. Hunter (*Non-Member*)	R. C. Knowles (*Non-Member*)
	R. B. Dale (*A.S.M.E.*)	H. L. Cameron (*Non-Member*)
Goldberg, Moses, Student, Pratt Institute, Brooklyn, N. Y.	J. W. Hunter (*Non-Member*)	R. C. Knowles (*Non-Member*)
	R. B. Dale (*A.S.M.E.*)	H. L. Cameron (*Non-Member*)
Greenland, Sidney F., Htg. & Vtg. Engr., London, England.	W. W. Nobbs	A. F. Browne (*I.H.V.E.*)
	W. G. Case	P. C. Whitaker (*I.H.V.E.*)
Haden, G. Nelson, Joint Managing Director, G. N. Haden & Sons, Ltd., London, England (*Advancement*).	W. N. Haden	Walter Yates
	W. W. Nobbs	Edgar Herring
Hamlin, Chauncey J., Jr., Proprietor, Hamlin Air Conditioning Co., Buffalo, N. Y.	B. C. Candee	G. F. Erdle
	M. C. Beman	W. F. Johnson